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INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

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Devoted to Measurement and Control Problems

Vol. 4. No. 4 Pittsburgh, Pa. April, 1931

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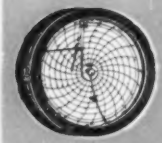
- Collins Viscosity Tube
- New Binocular Research Microscope

Place initials of interested persons in your organization opposite title and call it to their attention.



RECORDING THERMOMETERS AND PRESSURE GAGES

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DIAL - INDICATING THERMOMETERS

OIL TESTING INSTRUMENTS, THERMOMETERS, HYDROMETERS, ETC

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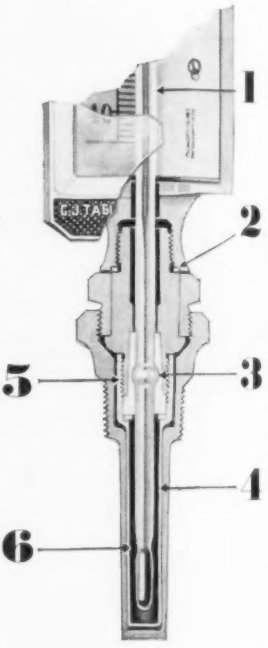

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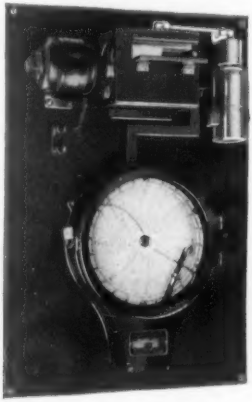
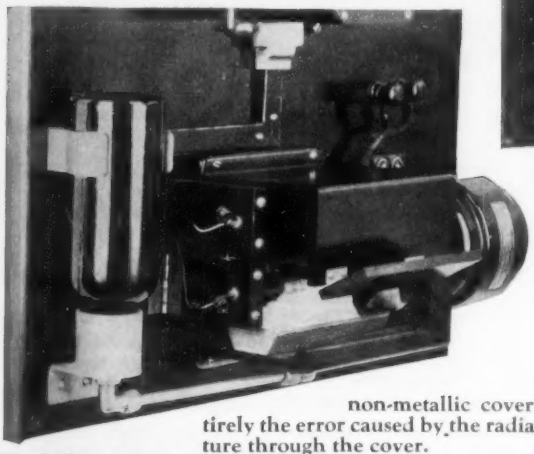
New Wet and Dry Bulb Thermometer Fixture

A NEW Wet and Dry-Bulb Thermometer Fixture, recently placed on the market by The Bristol Company, eliminates, to a large degree, the errors common in such devices.

In the past, it has been the practice to enclose the wet bulb with a metal cover and circulate air over the bulb by means of a fan and motor. With this equipment, the wet bulb depression was always less than the depression as obtained with a standard sling psychrometer. The results were always disappointing; that is, the greater the depression the greater the error.

A *non metallic* cover has been used on the new fixture, arranged to have around the bulb a large amount of space for the circulation of air. This non-metallic cover eliminates almost entirely the error caused by the radiation of room temperature through the cover.





Above is shown complete panel, including Recording Instrument, motor, fan, bulb housing and bottle of water. At left is a close-up of the new fixture.

The bulbs are held in position by non-metallic brackets so that the temperature of these brackets cannot affect the bulb temperatures.

The water pan is shallow and wide so that a large surface of water is exposed to the circulating air. This causes the water to evaporate from its surface and thus cooling it to a temperature near the wet bulb temperature. In this way water of the proper temperature is supplied to the bulb.

No soft soldered joints are supplied in the water system so that water corrosive to solder can be used.

Results from this wet and dry bulb fixture are very close to the standard sling psychrometer.

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Weston Model 576

For Direct Reading of

MUTUAL CONDUCTANCE *of Radio Tubes*

WESTON MODEL 576

THIS new Weston model 576 Mutual Conductance Tester reads the mutual conductance of all type A.C. and D.C. radio receiving tubes, having an amplification factor between 3.5 and 42, and screen grid tubes.

Radio tube manufacturers, set manufacturers with tube problems, large radio distributors and service organizations will find immediate use for this new and additional means to better check radio tubes.

Model 576 employs a newly developed copper oxide rectifier circuit. The meter is 7¼ inches in diameter—made for flush panel mounting. It is accompanied by a "Compensator," a separate rectangular unit arranged for surface mounting on the panel, adjacent to the instrument. The "Compensator," by means of a dial switch, permits an easy change-over from one type tube to another.

The operation of Weston model 576 is based on the application of a signal voltage of one volt A.C. 60 cycles to the grid. The other elements of the tube are energized with their standard rated voltages.

Weston Mutual Conductance Testers can also be supplied in smaller sizes, without the "Compensator," for use in a production line devoted to a single type of tube.

Write for Complete Details

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Many accurate methods of H-Ion determination are not suitable for routine work because they are slow and difficult. More speedy methods suffer for want of accuracy. The B & L H-Ion Colorimeter combines these two important qualities, giving the routine worker an ideal instrument for pH work to close limits of accuracy.

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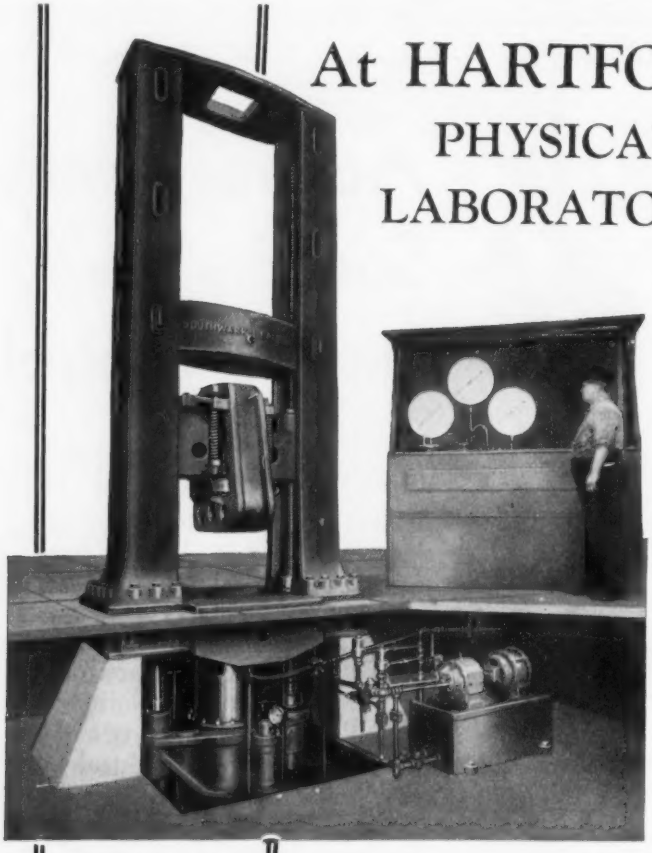

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Literature upon request

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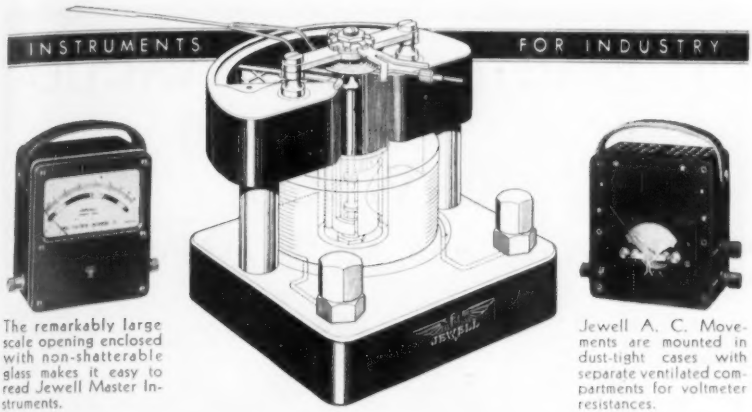

The remarkably large scale opening enclosed with non-shatterable glass makes it easy to read Jewell Master Instruments.

Jewell A. C. Movements are mounted in dust-tight cases with separate ventilated compartments for voltmeter resistances.

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employs an old principle in the modern manner

The repulsion of similar magnetic poles was discovered long ago. The Jewell Style D Iron Vane Movement employs this ancient principle in the modern manner. For true simplicity, no electrical measuring instrument can compare with the iron vane movement used in Jewell Master A. C. Voltmeters and Ammeters.

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Pattern 174— VoltAmp Wattmeter
Pattern 175— PolyphaseWattmeter
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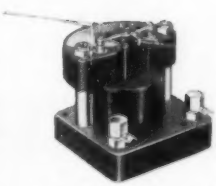

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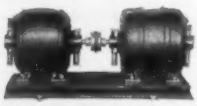
Universal Laboratory Motor

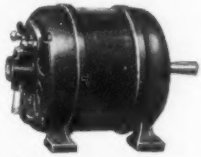
This portable variable speed laboratory power unit operates from any 110 volt lighting circuit, either direct or alternating current up to 60 cycles. The speed is adjustable with a rheostat in the base from standstill up to 6000 R. P. M. under full load.

The double swivel joint permits the motor to be tipped at an angle. The extreme flexibility of this mounting adapts the unit to the miscellaneous requirements of lecture room or laboratory work. Furnished with type CR gear reducer motors also.

Other Bodine Motors for Laboratory and Industrial Service



Motor Generator Sets and Dynamotors are ideal for battery charging, telephone ringing, therapeutical appliances, etc. Send for Bulletin 1001-A.



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With L&N POTENTIOMETER PYROMETERS

HERE is a fundamentally different *type* of instrument: the L & N Potentiometer Pyrometer*. It is an electrical balance—with a known *millivoltage* on one side and the unknown on the other. It does not measure the flow of *current* in the thermocouple circuit; it opposes the *millivoltage* of the thermocouple with a known *millivoltage*—and the length of the leads in the circuit does not matter. They can be lengthened or shortened—with the L & N Potentiometer Pyrometer continuing to record the temperature accurately.

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Information as to the advantages of L & N Potentiometers will be sent on request.

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Different Pyrometers—The Most Accurate Pyrometers In Industry
For Indicating, for Recording and for Controlling Automatically

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Richard Rimbach, Managing Editor **M. F. Béhar**, Engineering Editor

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—Quickly and Accurately

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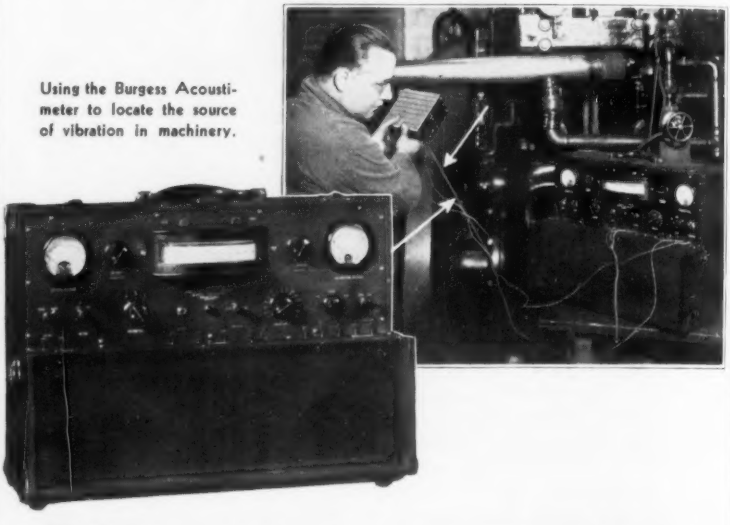

Using the Burgess Acoustimeter to locate the source of vibration in machinery.

THE Burgess Acoustimeter is a modern instrument designed to meet the ever increasing demand for a simple, accurate and scientific measurement of noise and vibrations. It has been successfully applied to the measurement of city noises, office noises, gear noises, machinery vibrations, detonation, architectural acoustics and similar commercial problems.

Write for Bulletin No. E9

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DIVISION OF C. F. BURGESS LABORATORIES INC.
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EDITORIAL COMMENT

Hail to the Plant and Sales Engineers!

ON the whole, the general business depression did not cause a slump in instrument sales, since many progressive plants placed large orders for industrial types of indicators, recorders and control systems. It appears that in these last fifteen months makers and dealers specializing in the laboratory business have found this business hard to get; the full-line firms serving both fields have just about maintained their rate of growth; but the manufacturers of industrial instruments, as a group, actually sold more than ever.

Scribbling and speechifying statesmen, seers and spokesmen have overlooked this bright spot on the generally dark industrial map Which is regrettable, because the story of the industrial instrument business throughout the depression is more inspiring than the vague and verbose vaporings of visionaries. Things do not "just happen," and back of the current growth of Instrumentation are definite causes, well deserving the attention of economists seeking means of smoothing out the sawtooth curves of production, consumption, employment, money, purchasing power, credit and dividend disbursements

Two groups of men deserve the credit—the buyers and the sellers. Let us consider each in turn to see why, during the depression, more industrial instruments were *bought*, and why more were *sold*.

In times of prosperity the management of an industrial plant is chiefly worried about maintaining production rates and keeping shipping promises. Production costs are secondary. Process steam, for example, is believed to "cost nothing" where steam is primarily generated for power and light; and conversely, electric power and light costs are disregarded where steam is generated primarily for processing applications. Engineers are too busy to undertake instrumentation surveys and the management is too busy to consider assigning engineers to look for places where meters and controls could cut costs.

But hard times bring enforced leisure, and vanishing margins of profit compel that this leisure be utilized in breaking down and cutting down all costs. The need of meters for ascertaining costs, and of automatic devices for cutting costs, then becomes apparent. "Why didn't we buy instruments when we were flush?" is the tenor of the conclusions; "Let's install them *now*!" is the decision of progressive plant engineers.

Plant engineers therefore deserve credit—but in our opinion they deserve exactly one-half of the credit: the other half should go to the instrument makers who have not only developed indicators, recorders, integrators and controllers, but who have patiently studied the needs of their prospects and persistently carried on campaigns of education. This other fifty percent of the credit must therefore be meted out to all those who paved the way for the phenomenal purchases of industrial instruments which have been and are still being made—to research and development men, to alert sales managers, to capable advertising managers, to technical journals that

have promoted Instrumentation (no need of our being over-modest in this connection), to the higher executives, but above all to the men on the firing line—to the sales engineers of the instrument companies It matters not how well the way was paved: these men had to fight nevertheless, and every order was the outcome of an intelligent engineering presentation There are numerous instances of instrument sales engineers who for *years* had painstakingly surveyed the plants of their prospects (with the courteous assistance, of course, of the plant engineers) and who had thus largely paved their own way by being able to answer technical questions, display an intimate knowledge of the application, and present detailed figures of expectable results.

Among these thousands of plant engineers and sales engineers who have thus lined with silver the clouds of depression, there is probably not a single one who has indulged in making speeches or writing articles on how to restore industrial prosperity . . . they were too busy *showing* one way.

First Exhibit of Testing Apparatus and Machines

THE FIRST Exhibit of Testing Apparatus and Machines will be a feature of the Thirty-Fourth Annual Meeting of the American Society for Testing Materials in Chicago, June 22 to 26. It will be held in the Exhibition Hall of the Stevens Hotel. Every facility for operating equipment, including gas, compressed air, electricity, steam, and water has been provided. It is planned that the Exhibit shall have the scientific and broadly educational atmosphere consistent with the technical nature of the Society's activities. These activities cover practically every type of test, including determination of chemical composition of materials, physical constants, mechanical properties and electrical, magnetic, thermal, and metallographic properties. It is desired, therefore, to emphasize the design, construction, and use of apparatus; its adaptability to standard and special tests of materials; and the development of new apparatus and new tests.

The exhibit is limited to apparatus, equipment, and machines used in the testing of materials. Recording and control equipment, if used in testing, may be shown; but it is not intended to include devices and machines used only in processes of production since these are outside the field of the Society's activities. Within these limits, the Society will consider for display all equipment produced or distributed by responsible individuals and companies of good standing, in the industry. In the interest of the exhibitors, the limiting capacity of testing machines exhibited has been set at approximately 100,000 pounds.

Emphasis is placed on the value of exhibiting new and unusual apparatus that will be of particular interest to committees of the Society in the development of testing materials. Many of the exhibitors plan to show for the first time apparatus produced this year, and it is expected that distributors of equipment developed abroad will have several machines of unusual interest on display.

Weights*

Richard Rimbach

A "WEIGHT" in the measurement sense of the term is a body of known mass. Since a really adequate definition would require several pages, and since this has been done satisfactorily by various authors, only a few brief notes are needed here. The reader doubtless knows that mass is quantity of matter and doubtless remembers the Newtonian law that all bodies attract one another with a force proportional to the product of their masses and inversely proportional to the distance between their centers of mass. In weighing with balances, use is made of the earth's attraction on the two masses in the scale pans, in the riders, etc., while the attraction of these smaller masses for one another is considered zero. Thus a standard weight is a known and calibrated standard mass possessed by a body of suitably stable material suitably shaped for the purpose. The reader also knows that the gravitational pull varies with location on the actual surface of the earth and that this variation plays no part in the comparison of masses by means of balances, seriously as it affects weighing by means of elastic-member instruments.

Names have been assigned to the various standards, and to the systems of standards. Likewise the relationships among the various systems have been gradually established with an increasing degree of refinement, and promulgated by governments and other authorities. For the history of weights with special reference to the science of weighing and to the metric system, see "Measurements, Industrial and Scientific" by Dr. Walter Block, INSTRUMENTS, Oct. 1929, page 337. For a complete discussion of the United States standards see the paper by Louis A. Fischer on the History of the Standard Weights and Measures of the United States, published as Bureau of Standards Miscellaneous Publication No. 64. A briefer discussion of this subject, by R. W. Smith of the Bureau of Standards appeared in the February 1931 Scale Journal, from which the following is still more briefly abstracted:

Colonial weights were of English origin, and correspond to those in use in England prior to the formation of the Colonies. There was considerable divergence among the weights of the several colonies, and this persisted after the formation of the Union. Repeated efforts were made to have Congress correct this condition. Finally, in 1828, Congress decreed that a certain Troy pound which had been procured in England, and which was supposed to be an exact copy of the imperial troy pound of Great Britain, should thereafter be the standard for the coinage of the United States. Two years later Congress ordered that a comparison be made by the Treasury-department of the weights at the principal custom-houses. Large individual discrepancies were found, but the average values for the different denominations were found in fairly good agreement with the weights used in England at the time of the Revolution. In order to construct uniform weights to be furnished the custom-houses, the Treasury Department found it necessary to adopt a definite standard; it was decided that the relation between the avoirdupois pound and the troy pound of the Mint should be as 7,000 is to 5,760, this being the relation previously accepted in the United States and in England.

*Conclusion of Chapter I of Handbook of Laboratory Instruments and Apparatus.

Uniform standards having been furnished to the custom-houses, Congress in 1836 directed that copies of these be furnished the several States, and as additional States were admitted to the Union they were also supplied with standards; North Dakota, in 1893, was the last State to receive one of these sets.

In 1870 there was held in Paris a conference to which various nations had been invited by the French Government to send representatives to consider the advisability of constructing new standards of the metric system. This and subsequent conferences were attended by representatives of the United States, and these meetings resulted in the decision to construct new metric standards, and in the signing of a treaty providing for the formation and maintenance of the International Bureau of Weights and Measures.

New metric standards having been constructed by a special committee appointed for that purpose, these were compared with the old metric standards by the international bureau and at a general conference held in 1889 the new kilogram which agreed most closely with the kilogram of the Archives was declared to be the international kilogram, the other kilograms were distributed by lot to the various governments supporting the international bureau, the United States receiving kilograms Nos. 4 and 20. These were brought to this country in 1890, and were deposited in the Office of Weights and Measures of the Coast and Geodetic Survey. On April 5, 1893, the Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, decided that the international kilogram would in the future be regarded as the fundamental standard of mass in the United States, both for metric and customary weights.

The Office of Weights and Measures used as the relation between the avoirdupois pound and the kilogram the equivalent, one pound avoirdupois equals 0.4535924277 kilogram, a value determined by the joint work of the International Bureau of Weights and Measures and the British Standards Office. When the National Bureau of Standards was established in July, 1901, the decision of the Office of Weights and Measures to recognize the international kilogram as our fundamental standard of mass, and the equivalent just given as the relation between the avoirdupois pound and the kilogram, were fully accepted by the Bureau and are so accepted today.

When we speak of a "standard" weight we mean a weight which is standard according to some accepted basis. The following statement represents the practice accepted in the United States as that upon which weights of Classes A, B and C* are to be considered standard:

The calibration is based upon the apparent mass as determined at 20°C in air having a density of 1.2 milligram per milliliter against standards having a density of 8.4 grams per cubic centimeter at 0°C, whose coefficient of cubical expansion is 0.000054 per degree centigrade, and whose values are based on their true mass or weight in vacuo. The factors just mentioned are discussed in Circular No. 3 of the Bureau of Standards, Design and Test of Standards of Mass.

To sum up, then, the situation in relation to the United States avoirdupois pound is this: The pound is defined in terms of the kilogram, the relation being, 1 pound avoirdupois equals 0.4535924277 kilogram. The international kilogram, preserved at the International Bureau of Weights and

*See below under procedure for Bur. of Stds. checking.

Measures, Sèvres, France, is our fundamental standard of mass; our national primary standard is the kilogram preserved at the Bureau of Standards, the value of this in terms of the international standard being known with the highest accuracy attainable by the modern metrologist.

The United States primary kilogram is used upon rare occasions to verify the accuracy of the reference standards of the mass laboratory of the Bureau of Standards, which, in turn, are utilized to check the accuracy of the laboratory's working standards. These latter standards are of various denominations, suitable for the comparison of weights submited to the Bureau for test.

Apparent *versus* True Value of Weights—As weights are buoyed up by the surrounding air by amounts dependent upon their volumes, all fundamental standard weights should theoretically be of the same material of the same densities. If two such weights balance in air of a certain density, they will also balance in air of a different density and in a vacuum. Brass is usually employed for standards of weight, although platinum, platinum-iridium and quartz have been used for the smaller standards. Commerical standards are of brass, bronze or iron, depending upon the accuracy involved and the intended use. In the absence of definite knowledge, of the actual density of a weight, those made of brass are assumed to have a density of 8.4 at 0°C., while platinum weights are assumed to have a density of 21.5 at 0°C.

In practice, the standard analytical weights are of brass in the sizes from 1 g. upward, while the smaller weights are of platinum, nickel-silver or aluminum. As tantalum is not attacked by nitric, sulphuric or hydrochloric acid, nor by aqua regia or the alkalies, and as it is now becoming cheaper than platinum, it is now made up into smaller weights by one manufacturer (*Becker*). As tantalum is attacked to some extent by hydrofluoric acid, the use of this metal for weights should be guarded against where that acid might come into contact with the weights. However as the price is below that of platinum and the corrosion-resisting properties are greater than those of aluminum and nickel-silver, these weights seem to fill a definite need. Balance riders are still made of platinum, platinum-iridium or aluminum.

Most makers of weights supply their products "adjusted to their apparent weight in air, against brass standards," the brass standards being in turn adjusted to their real mass (or weight in a vacuum). The true weight or mass of weights made of material other than brass, may vary considerally from their nominal values, as in the case of platinum, aluminum and quartz. When sets of weights are calibrated, this should be taken into consideration and the apparent weights adjusted for this discrepancy. The National Bureau of Standards will usually certify weights on either basis.

Commercial weights are all used in air and the basis of apparent weight in air is usually the one employed for standardization. Most countries have legal definitions and codes covering this. Scientific weighing is based on true mass values (weight in vacuum), but most of the smaller weights can be used as though they were of brass, without serious error, except in the most precise work, where a correction* for buoyancy should be applied.

*For method of applying this correction, see International Critical Tables, Vol. 1, page 74.

Fig. 46. Set of precision analytical weights in late model bakelite box. Bronze to 1 g, platinum or gold 500 to 50 mg and aluminum 20 to 1 mg. (*Wm. Ainsworth & Sons*).

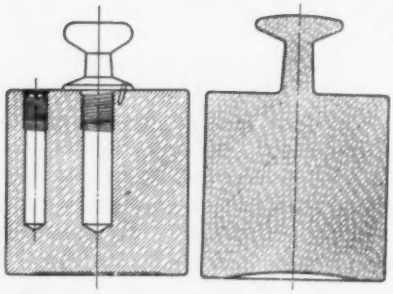

Fig. 47. Section of Class C precision weight. Brass, with lead-shot cavity. (*W. & E. Gurley*).

Fig. 48. Section of Class A precision weight. Single piece of Tobin bronze. (*W. & E. Gurley*).

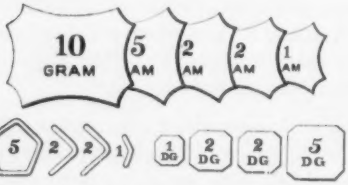

Fig. 49. Metric prescription weights suitable for photography, botany, color, dye and paint weighing. (*Henry Troemner*).

Fig. 50. Set of rock crystal weights in case, with ivory tipped forceps. Weights are one-piece. (*August Sauter*).

TYPICAL WEIGHTS OF FREQUENTLY USED CLASSES

CONSTANCY OF WEIGHTS

Much work has been done at the U. S. Bureau of Standards on the constancy of weights. This is reported by A. T. Pienkowsky in the International Critical Tables, Vol. 1, page 74. It may be summed up as follows: Ordinary brass weights with screwed-in knobs (whether gold-plated, platinum-plated or lacquered) may continue to gain weight for many years without developing visible signs of such changes. The following is a typical case of what may be expected of new weights which were not used, and carefully protected.

Weight in g.	100	50	20	10	5	2	1
Gain in weight in 5 months, in mg.	0.1	0.1	0.0	0.1	0.1	0.0	0.0
Gain in weight in 1 year, in mg.	0.2	0.1	0.0	0.1	0.1	0.0	0.0

Weights in use will naturally show a greater variation.

Weights in use will naturally show a greater variation.

Lacquered weights of good quality are less subject to spotting and general surface tarnishing than most plated weights. These may, however, be subject to rapid variations due to moisture absorption and loss, due to humidity conditions obtaining during their use. Changes up to 0.5 mg. have been recorded for 100 g. weights.

For reference standards the one piece weights have been found to be less variable. The smaller weights vary somewhat, losses of about 0.01 mg. might be expected, even though the weights are not used frequently and then with care.

Several years ago, chromium-plated weights were introduced, with the purpose of overcoming the objections of the lacquered weights. According to private advices, there seems to be a tendency for these weights to increase in weight, probably due to hygroscopic chromium salts enmeshed in the electro-plated coating. Due to the hard deposits possible with chromium it is quite possible that such weights will become popular if methods of electroplating can overcome the present objection. Weights made of an alloy steel called "Invar" have appeared but do not seem to have entered the field to any great extent.

HOW TO HAVE WEIGHTS CHECKED BY THE U. S. BUREAU OF STANDARDS

Weights used in commercial transactions should be tested by local or state weights and measures officials or office, frequently known as the state Bureau of Standards. They are accepted for test by the National Bureau of Standards at Washington, D. C. only under exceptional circumstances. Standard weights are however checked by the National Bureau, which tests them and certifies as to their accuracy by issuing a certificate or report as the case might require. The National Bureau does not manufacture or sell standards, nor does it adjust or correct weights submitted for test, except in rare instances.

Weights may be submitted for test by the manufacturer or by the user. When considering the purchase of weights of standard accuracy, the purchaser should specify that the weights must come up to the specifications of the Bureau of Standards and be supplied with the Bureau's Certificate of Accuracy. Such weights may be shipped directly from the manufacturer's factory or warehouse and, after test, forwarded by the Bureau to the purchaser.

METRIC WEIGHTS AND EQUIVALENTS

Milligrams (mg)	Centigrams (cg)	Decigrams (dg)	Grams (g)	U. S. Equivalents	British Imperial Equivalents
1	0.1	0.01	0.001	0.015432356 grain	0.01543236 grain
10	1	0.1	0.01	0.15432356 grain	0.1543236 grain
100	10	1	0.1	1.5432356 grains	1.543236 grains
				15.432356 grains	15.43236 grains
1000	100	10	1	0.5643833 dram av.	0.564383 dram av.
				0.03527396 ounce av.	0.0352739 ounce av.

Grams (g)	Dekagrams (dkg)	Hectograms (hg)	Kilograms (kg)	U. S. Equivalents	British Imperial Equivalents
				0.771618 scruple	0.77162 scruple
1	0.1	0.01	0.001	0.2572059 dram apoth.	0.64301 pennyweight
				0.03215074 ounce apoth.	0.03215 ounce troy
				0.0022046 pound av.	
10	1	0.1	0.01	5.643833 drams av.	5.64383 drams av.
100	10	1	0.1	3.527396 ounces av.	3.52739 ounces av.
				2.204622341 pounds av.	
1000	100	10	1	2.6792285 pounds Troy or apoth.	2.2046223 pounds av.

1 kilogram = 15432.35639 grains = 0.00110231 short ton = 0.00098421 long ton.
1 metric carat = 200 milligrams = 3.0864712 grains.
1 myriagram = 10,000 g. = 10 kg. = 22.04622 pounds av.
1 quintal = 100 kg. = 220.46 pounds av.
1 millier or tonne = 1000 kg. = 220462. pounds av. = 2679.23 pounds troy = 0.98420640 long ton = 1.1023112 short tons.

PREFIXES

The prefixes mega-, meaning one million, and micro-, one millionth, are used in connection with various simple and derived units of the metric system.

A written request for the testing should be forwarded to the Bureau at the time the weights are shipped. This request should show the class of weights being submitted and the kind of test desired. All weights, whether sent singly or in sets, should bear identification marks, for the convenience of the Bureau.

All weights are cleaned by the Bureau before test. If it is desired to know the exact weight of weights submitted at the time of submitting, in order to make corrections in work done with the weights before the Bureau's test, a definite statement should be made to the Bureau to that effect. This should be made sufficiently in advance, to enable the Bureau to separate the weights from the others which would ordinarily be cleaned without the preliminary weight calibration.

All weights should be carefully and tightly packed to prevent damage during shipment. It is a good idea to put extra packing inside the case to prevent shifting of weights during transit. Weights should be sent directly to the U. S. Bureau of Standards, Washington, D. C. or may be shipped to any of the laboratory supply houses, which will in turn, forward them to the Bureau. Practically all of the larger supply houses will render this service to their customers.

Classes of Standard Weights—Six "classes" of standard weights are recognized and tested by the Bureau. Of these, Classes A, B and C form the commercial group while Classes M, S, and S2 include laboratory standards.

Class A standards are required to be made of a single piece of metal. The larger weights of this class are, at the present time, usually made of bronze, gold-plated. They are intended for such purposes as primary

U. S. AVOIRDUPOIS WEIGHTS AND METRIC EQUIVALENTS

Grains (gr.)	Drams (dr. av.)	Ounces (oz. av.)	Pounds (lb. av.)	Tons (short) (tn.)	Metric Equivalents
1	0.03657	.....	.....	.....	0.06479818 gram
27.34375	1	0.0625	.....	.....	1.771845 grams
437.5	16	1	0.0625	.....	28.349527 grams
7000.	256	16	1	0.0005	453.5924 grams
					0.4535924 kilogram
.....	.....	32000	2000	1	907.18486 kilograms

1 pound avoirdupois is the mass of 27.692 cubic inches of water weighed in air at 4°C., 760 mm. pressure
1 short hundredweight (cwt.) = 100 pounds = 45.359243 kilograms
1 short ton = 20 short hundredweight = 2,430.56 troy pounds = 907.18486 kilograms
1 stone (British) = 14 pounds = 6.350 kilograms
1 quarter (British) = 28 pounds = 12.70 kilograms
1 long hundredweight (British) = 4 quarters = 112 pounds = 50.802352 kilograms
1 long ton (British) = 20 long hundredweight = 1016.04704 kilograms
1 long ton = 1.12000 short tons = 2722.22 troy pounds = 1.01605 metric tons
1 short ton = 0.89287 long ton = 29,166.66 troy or apothecaries' ounces = 0.90718 metric ton
1 avoirdupois pound = 1.21528 troy or apothecaries' pounds = 14.5833 troy ounces
1 avoirdupois ounce = 0.9115 troy or apothecaries' ounce = 0.00044643 long ton = 0.00045359 metric ton

U. S. TROY WEIGHTS AND METRIC EQUIVALENTS

Grains (gr.)	Pennyweights (dwt.)	Ounces (oz. t.)	Pounds (lb. t.)	Metric Equivalents
1	0.0416667	0.0020833	.....	64.798918 milligrams =
				0.064798918 gram
24	1	0.05	0.0041667	1.555174 grams
480	20	1	0.08333	31.103481 grams
5760	240	12	1	373.24177 grams

1 troy pound = $\frac{5760}{7000}$ or 0.822857 avoirdupois pound = 13.1657 avoirdupois ounces
1 carat (1877) = 3.168 grains = 205.6 milligrams
1 troy ounce = 1.09712 avoirdupois ounces
1 troy pound = 0.00036735 long ton = 0.0041143 short ton = 0.00037324 metric ton

U. S. APOTHECARIES' WEIGHTS AND METRIC EQUIVALENTS

Grains (gr.)	Scruples (℈ or s. ap.)	Drams (ʒ or dr. ap.)	Ounces (℥ or oz. ap.)	Pounds (lb. ap.)	Metric Equivalents
1	0.05000	0.016667	0.0020833	.....	64.798918 milligrams
20	1	0.3333	0.041667	0.003472	1.2959784 grams
60	3	1	0.12500	0.010416	3.8879351 grams
480	24	8	1	0.08333	31.103481 grams
5760	288	96	12	1	373.24177 grams

State standards. The correction for each weight, given to a high degree of precision, is included in the certificate, and new weights are given a three months' test for constancy.

Class B standards must be just as accurate as those of Class A, but the requirements as to structure are not so severe, and they are certified merely as correct within the required tolerances.

Class C includes high grade "test weights," such as are intended primarily for testing the scales and weights used in ordinary commercial transactions. The errors allowable on these weights are five times those of Class

B, but only one-tenth of the errors allowable on weights in use for ordinary trade. They are certified as correct within the prescribed tolerances.

Class M standards are required to be one-piece weights. They are suitable either for laboratory weighings of extreme precision such as one part in a million or better, or for very reliable reference standards. Either of two tests may be given them: the High Precision Test or the Moderate Precision Test. In both cases the correction for each weight is certified, but in the former test the corrections are certified to a higher degree of precision. To obtain this it is necessary to determine the volume of each of the larger weights by hydrostatic weighings. In the Moderate Precision Test the corrections are certified only to the same precision as for weights of Class S, with the result that the density of the weights may generally be assumed from the average density of the material of which they are made.

Class S includes high grade "analytical," and similar laboratory weights. The larger weights are commonly made with a knob merely screwed into the body. These weights must not show excessive variations in value under ordinary variations in the humidity of the air. Either of two tests may be given these weights: the Determination of Corrections, or the Tolerance Test. In the former test the corrections are certified; in the latter the Bureau certifies merely that the errors are not more than the prescribed tolerances.

Class S2 includes laboratory weights of the grade commonly recognized as "second quality analytical" or "students' sets." The allowable errors are five times those of Class S, but the structure of the weights is generally about the same as in Class S. These weights are certified as correct within the prescribed tolerances.

Information as to the precision to which corrections will be certified for weights of Classes A, M, or S, and lists of tolerances for any class will be supplied on application to the Bureau. Full details as to specifications, tolerances, and precision of corrections together with other information as to standard weights and some of the methods of testing them are given in Bureau of Standards Circular No. 3, which may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of 15 cents.

Fees—Fees depend on the nature of the testing done. There are given in Test Fee Schedules 221 to 227 inclusive, copies of which will be supplied by the Bureau on request.

Fees are charged on all tests except those conducted for Federal or State institutions. Fees should be paid in advance.

Time Required for Tests—New Class A standards must remain at the Bureau for more than three months because of the 3 months' constancy test.

For an ordinary set of Class S weights a period of about two weeks is required to determine whether they are sufficiently stable under variations in the humidity of the air. The cleaning, testing, checking, packing, and certification are likely to extend through another week.

For weights of other classes the time required can not be as accurately estimated and periods of from two or three days to about one month may be required, depending on the precision necessary to be obtained and on the number and denominations of the weights. The tolerance tests can be made more quickly than the determination of corrections, largely because they do not require work of as high precision.

Certification and Shipment—When weights conform to the specifications and tolerances of one of the recognized classes of standards, a "certificate" is issued on completion of the test, and each weight of the commercial group is impressed with a seal, unless this is impracticable or inadvisable. For weights not conforming to the requirements a "report" is issued.

As a rule each set is treated as a whole, but when a few weights of a set are not sufficiently accurate the set may be split, a certificate being issued for the satisfactory portion and a report for the incorrect weights.

When certified weights are shipped from the Bureau, either the inner wrappings or the shipping case will be sealed, and will bear the Bureau of Standards Test Number together with any other numbers or letters that may be necessary for identification.

FACTOR WEIGHTS

In chemical analysis, the material sought is not always separated from the original sample in its native state but is more frequently separated or determined as a definite compound, calculations being resorted to, to determine the percentage composition in terms of the element sought. These calculations are frequently quite involved and time consuming. To obviate this, "factor weights" are used. The ratio of the molecular weight of an element or compound to another compound of that same element is called its factor. In an analysis, if a sample be taken such that its weight (in grams) is numerically equal to the factor, the weight of the material actually separated (also in grams) multiplied by 100, will give the percentage composition of the sample. Weights made on such a basis are called "factor weights." When it is not convenient to weight a sample equal to the entire factor weight, half, quarter or other fractional equivalent weights are used. Some of the more commonly used are the carbon, phosphorous, silicon and sugar.

The Assay-ton weight system has become so convenient that the industry has adopted it to the almost utter exclusion of the other weight systems.

The Assay-ton system of weights was devised by Prof. Charles F. Chandler of Columbia University, New York City. It saves much time in that by its use, the tedious calculations of assay analyses are eliminated. By taking an "assay-ton" or 29.1666 g. of material for a sample and weighing the final assay button in grams, the weight of the button in milligrams will be to the weight of the original sample as the number of Troy ounces of gold or silver per avoirdupois ton of ore. The assay ton is derived from the relative weights involved. One avoidupois ton contains 14,000,000 grains (2000 lbs. per ton and 7000 grains per lb.). One Troy ounce contains 480 grains. By dividing 14,000,000 by 480 we get 29,166.6 or the number of Troy ounces per avoirdupois ton. Thus if this number of milligrams of a sample be taken for analysis, each milligram of gold or silver in the button would correspond to an ounce of that metal per avoidupois ton of the ore. Ordinarily the sets of assay-ton weights will include the following weights: 1/20, 1/10, 2/10, 5/10, 1, 2, and 4 A. T.

For those interested in following up the subject of balances and weights the following periodicals will be found to contain a wealth of information.

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Belgium

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*Temporarily discontinued June 1929.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

Die Mundungsdampfmessung. *E. Praetorius & K. Hopfer.* Third volume of "Messen und Pruefen." Verlag von Wilhelm Knapp, Halle, 1930. Paper, 5½ x 8¼ inches, 90 pages. Price 5 RM.

This little volume represents an up-to-date summary of German practice in measuring the flow of steam by means of restricted openings in pipe lines. The term "Mundung" (mouthpiece) included in the title covers general types of restricted openings, the sharp edge orifice plates, the rounded nozzle, and the venturi tube.

Chapter 3, covering 52 pages, includes the fundamentals of steam flow measurement. The first division of this chapter is devoted to the derivation of the adiabatic equation for steam flow, but only a sufficient amount of theory is given to show the meaning of the corresponding terms which the authors adopted for practical use. The final working formula includes a discharge coefficient and two compressibility factors and a series of curves is given to evaluate these for variations in the condition of the flowing steam. Examples are shown for calculating the amount of steam corresponding to a given set of conditions. At the end of this chapter are sketches and construction details of the various forms of sharp edge orifices, nozzles, flanges, and venturis used in German practice.

The fourth chapter covers the details of installation of primary devices, selection of piping, necessary connections and other points of importance to the installation.

While the work is confined to the measurement of steam only, it could be extended to the measurement of gases by the addition of a few curves for the compressibility factor corresponding to the varying values of the expansion ratio. The pamphlet is most valuable for the description of the various primary devices. The method of applying the correction factors is somewhat different from the methods used in American practice.

In a book of this character, written for the operating engineer, one would have expected a more elaborate treatment of the experimental coefficients and correction factors—especially of their determination or "pedigree' which is by no means the simple and commonly understood matter the distinguished authors would have the reader believe. —J. M. Spitzglass.

Handbuch der allegemeinen Chemie. Elektromotorische Kraefte Electrolyse und Polarisation. Vol. 9, Part 1, of Ostwald-Drucker's Handbook of General Chemistry. By *R. Kremann & Robert Mueller.* Akademische Verlagsgesellschaft, Leipzig, 1930. Cloth, 9½ x 6¾ inches, 891 pages. Price 85 R.M.

This comprehensive reference book covers the theory of galvanic cells of all types and collects, in tables, about all the data available on the subject. It does not deal with fused salts as electrolytes, but is complete as regards aqueous electrolytes and includes what data exist on alcohols, aniline, and other organic electrolytes.

From the metallurgical point of view chief interest lies in the data on the potentials of various metals and alloys in various solutions, the discussion of the behavior of different types of alloy pairs from the equilibrium diagram point of view and the many points bearing on corrosion problems, such as the discussion of concentration cells, of oxidation and reduction phenomena, and all the factors affecting electrolytic attack and the precipitation of one metal by another out of solution.

The book is replete with references to the literature; the index covers 68 pages; the paper and printing are good, and the binding is solid enough to withstand the handling such a reference book will receive.—H. W. Gillett.

THE HANDBOOK OF INDUSTRIAL INSTRUMENTS

CHAPTER XI

Pressure Measuring Instruments

(Concluded)

M. F. Béhar*

17. Electrical Resistance, Piezoelectric, etc.

A number of methods of measuring pressure electrically have been proposed, but few have turned out to be practical. Among the satisfactory ones are some applicable only to high-vacuum work, and these will be dealt with in the next section. The remaining electrical methods may be divided into (1) resistance and (2) piezoelectric. The former may be divided into (*a*) contact resistance, and (*b*) resistance of wire or mercury conductors. Elimination is again needed in the case of the conductors, such methods not having reached the practical industrial stage. Contact resistance gages, on the other hand, are on the market in various standardized forms, have met with success and deserve adequate description here. Piezoelectric gages have not appeared on the industrial market in commercial forms but hold such interesting possibilities that a few paragraphs may be devoted to them at the end of this section. The great—and exclusive—advantage of electrical pressure responsive elements is the almost complete elimination of lag, making it possible to obtain with very little distortion records of the most rapid fluctuations ever met with in service. Sharp peaks in pressure curves are not likely to be rounded off where difficulties arising from friction and inertia are practically absent.

Another great advantage of electrical methods is that the displacements of moving parts occurring in the transmitting units are exceedingly small. In the case of piezoelectric crystals they are of ultra-microscopic order; in the case of the standard commercial model of the carbon-pile transmitter they are of micrometric order. This makes possible the measurement of *forces*, or of *mechanical pressures*, such as those under rolling-mill screws, etc. The combination of small displacement with negligible time lag makes possible also the measurement (and permanent recording) of instantaneous impacts, torque variations in drive shafts, strains in structural members such as locomotive frames, bridge members, etc. Here, then, is a class of instruments which is not restricted to the subject of this chapter, namely liquid or gas pressures, but can measure "force per area" (the broad definition of pressure) wherever it may exist—even in the midst of a "solid" body. The magnitude directly measured in the case of "rigid" members is strain or deformation (for a perfectly solid body does not exist) and its value gives—by calibration or by separate computation—stress or pressure at the time and point of measurement.

*Engineering Editor.

(a) Contact Resistance—The Telemeter

The principle of contact resistance as a function of pressure is illustrated in two familiar devices: the microphone or ordinary telephone receiver which is affected by the extremely feeble variations in air pressure set up by acoustic waves on one side of the disc, and the carbon pile rheostat which is also a highly *sensitive* device as proved by the very fact that vibrations render it useless for steady control. A modification of the latter has evolved from the usual crude arrangement used for rough control of current, into a successful industrial instrument unaffected by stray vibrations while responding to small variations in the measured pressure, and deservedly used on an increasingly large number of important applications. This interesting development began with the design of a carbon-pile strain recorder by B. McCollum and O. S. Peters (Bureau of Standards *Technologic Papers*, Vol. 17, p. 737). In 1928 E. J. Martin and D. F. Caris of the General Motors Research Laboratory adopted the McCollum-Peters Telemeter design and adapted it for the production of automotive engine cylinder pressure records (*S. A. E. Journal*, July 1928, p. 87-97). This Martin-Caris Indicator embodied improvements of an industrial nature. The Telemeter now on the market is shown in Figs. 346 to 352. There are various forms of each of the component units, so that numerous combinations are available for different industrial pressure applications.

Figs. 346 and 347 show two of the various styles of transmitters. The former is the regular form, with two carbon piles. A feature of interest is that no "gage line" is required—so that in the case of internal-combustion engines, for example, there can be no uncertainty as to whether the pressure affecting the measuring element is *the* pressure, at any instant. A thin diaphragm covers the threaded end of the frame and seals off the push rod which acts on the tongue between the two carbon pile resistors. The sum of the resistance changes in the two stacks is directly proportional to the pressure. These transmitters can be installed at relatively inaccessible points and are connected by a three-conductor rubber- or lead-covered cable to remote-indicating and-recording instruments. A number of transmitters may be connected to a central station panel board.

A unique "cartridge" form of transmitter is shown in Fig. 347. A is the steel frame. E is the carbon resistor, mounted within a rectangular portion of this frame, with ends slightly flexible. B and C are flanged bushings threaded into the frame. D is a steel cover tube. F is a resistance thermometer surrounding the carbon resistor, the resistance of which changes exactly 2 ohms for every 1°C change in temperature .S is a flexible seal made with rubber tubing and asphalt. At L three wires emerge from a sealed entrance, one of which is common to the resistor and to the coil. The seals prevent entrance of moisture, and under test have withstood 750 lb per sq. in. hydrostatic pressure for two hours without leakage. A cartridge similarly sealed except lacking rubber tubes S has been kept in saturated concrete for 2½ years without showing effects from moisture. The cover D is painted and wrapped with tape to prevent bond with the concrete. Flanges B and C, of course, are bonded with the concrete, and move with it. Relative motion between B and C changes the resistance of the resistor E. From this change of resistance, the corresponding change of length is determined by reference to a calibration curve which is supplied with each cartridge.

For automotive and aviation engine testing there is a form of transmitter which combines a spark plug and is screwed into the cylinder head in lieu thereof. It is described in detail in *The Electric Journal*, Feb.-Mar. 1930. This transmitter has a very stiff frame to avoid distortion when used on rough engines. It also has an air duct for cooling parts subjected to engine heat. Fig. 350 shows a typical oscillogram.

A noteworthy feature of the carbon-pile pressure transmitter is the flexibility of its range, which is secured by changing the voltage impressed on the carbon resistors. A transmitter designed for a maximum of 1500 lb per sq. in. for instance, can be used at 300, 500 and 1000 lb per sq. in. with full scale indication or record by suitably adjusting the operating voltage.

The range of pressure for which the transmitter can be adapted is wide, running from one ounce to 40,000 lb per sq. in. The standard instrument will cover the ranges of 0-100 to 0-2500 lb per sq. in.

Hysteresis effects have been made small, and the erratic performance heretofore observed in carbon-pile rheostats has been eliminated by the development of a new form of carbon-pile which differs first in the heat treatment of the carbon disc and its preparation and mounting, second in the use of mounting frames without mechanical joints, and third in keeping the stack under such pressure that only a small part of its pressure-resistance range is utilized. This pressure also renders the pile highly resistant to change from transverse shock, and a transverse acceleration due to shock of 330 times gravity can be withstood without altering instrument readings.

Peters found that Telemeter equipment will show total errors ranging up to 1% for slowly varying pressures; up to 3% for frequencies under 100 cycles per second; up to 5% for impact conditions, and 10% for the most severe impact, such as a heavy uncushioned hammer striking a steel body.

Indicating and Recording Instruments

In connection with Telemeter pressure transmitters there have been adopted several reading instruments, the selection of any of which depends upon individual conditions. For indicating only, there are panel boards as shown in Figs. 349 and 352, with voltmeters and rheostats for regulating the voltage in the circuit for the purpose of obtaining different ranges; and with millivoltmeters on which the readings of steady or slowly varying pressures may be observed. These panel boards and instruments correspond to similar industrial arrangements for indicating the temperatures of a number of resistance thermometer coils.

For the production of records, the choice of instrument depends on the frequency of pressure variations. For frequencies under ten cycles per minute and for variations which can thus be classified, an especially-built Leeds & Northrup potentiometer recorder is supplied, as shown in Fig. 348.

The recorder can be located at any distance from the transmitter. The length and resistance of the lead wires are of importance only as they affect the sensitivity of the galvanometer. In all cases the resistances of the leads have no effect upon the accuracy of measurement. The sensitivity of the appratus is a direct function of the voltage. The potentiometer itself is used as a recording voltmeter for adjusting the voltage of the pressure measuring circuit. The instrument has a range of ten volts and accurate to 0.02 volt. The change-over from pressure recorder to recording voltmeter is effected by pressing a button switch on the recorder panel. The two rheostats are provided on the panel for coarse and fine adjustment of the voltage.

The chart is driven by a synchronous motor which assures uniform speed. The speed cna be adjusted to any specified value up to ten inches per minute. The self-balancing mechanism causes the tracing pen to follow accurately small and relatively rapid changes of pressure. The instrument may be equipped with control discs to operate relays so that the pressure may be held constant or within predetermined limits.

The initial zero position of the system is established by an additional slidewire provided on the inside panel. By changing the voltage on the carbon resistors in the pressure transmitter the scales of the recorder may be varied in the ratio of one to five, that is, the minimum pressure for full scale record may be one-fifth the maximum. The accuracy of the system at all ranges is of the order of one percent which corresponds to one division on the 100 division chart. The chart is 10 inches wide. The effect of temperature is inappreciable within the normal range.

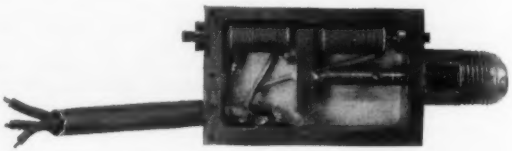
For obtaining records of rapidly varying pressures, the McCollum-Peters oscillograph is available in various camera models.

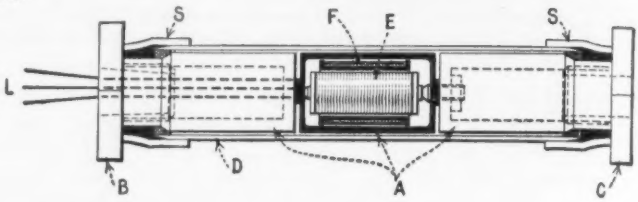
This oscillograph is especially adapted for recording transient pressures of short duration. The record is made with a beam of light acting upon a moving photographic film or paper. The inertia of the moving parts is so small that pressure fluctuations up to 1000 per second may be accurately recorded. These measurements are of importance in the study of explosions, water hammer, pressure ripples, and transient pressures in gases and liquids. Simultaneous records up to twelve in number may be taken on the same film. Pressures and strains can be coordinated.

Figure 348 shows a six-element oscillograph with camera and panel board. The recorder can be fitted with a rotating mirror, automatic shutter and plate holder to obtain photographs of standing waves. For very high film speeds, a special high-speed drum camera can be provided. (See Fig. 352). A six-inch wide film or paper is used for six simultaneous records or less, and twelve-inch for twelve records.

Fig. 346. Pressure transmitter with one cover plate removed exposing the two carbon resistors, etc.

Fig. 347. Sectional drawing of another form, the Cartridge Telemeter, designed for permanent location as inside a concrete wall, etc. See text.





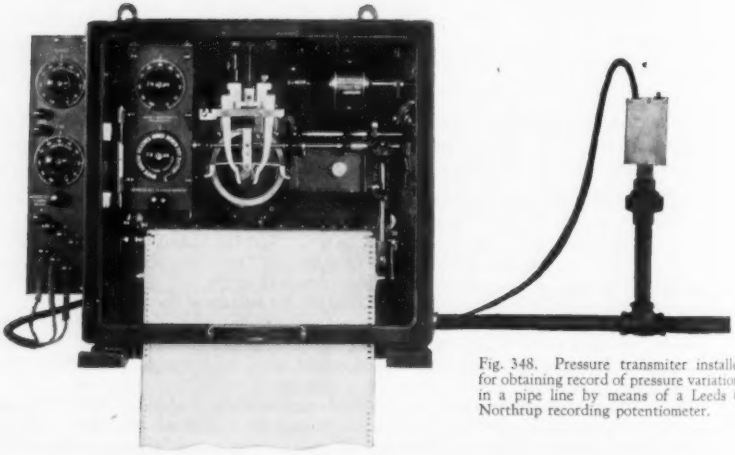


Fig. 348. Pressure transmiter installed for obtaining record of pressure variations in a pipe line by means of a Leeds & Northrup recording potentiometer.

Fig. 349. Six-element recording outfit with McCollum-Peters high-sensitivity oscillograph. (Driving motor and storage battery are not shown). Pressure fluctuations up to 1000 per second may be recorded.

INDUSTRIAL ELECTRICAL-RESISTANCE SYSTEMS FOR MEASURING

(Illustrations on both pages

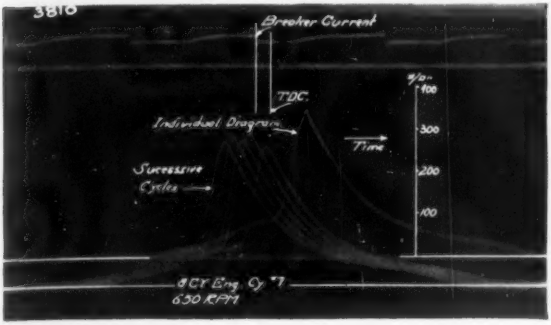


Fig. 350. Composite indicator card obtained from an oscillograph connected to Martin-Caris engine-indicator transmitter which is similar to that shown in Fig. 346. The individual diagram is higher than the others because its zero line is higher. (courtesy General Motors Corp.)

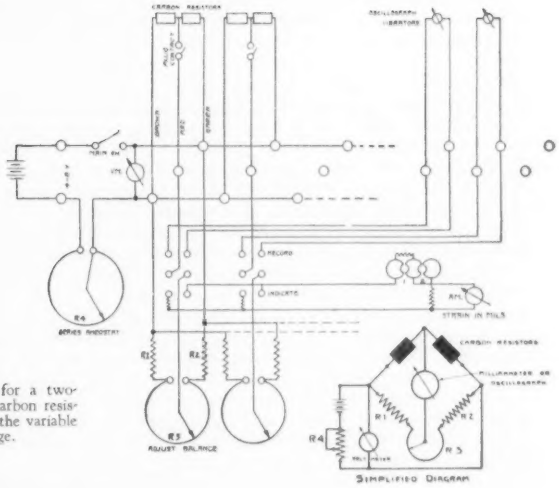


Fig. 351. Wiring diagram for a two-element circuit. The two carbon resistors of each element become the variable arms of the Wheatstone bridge.

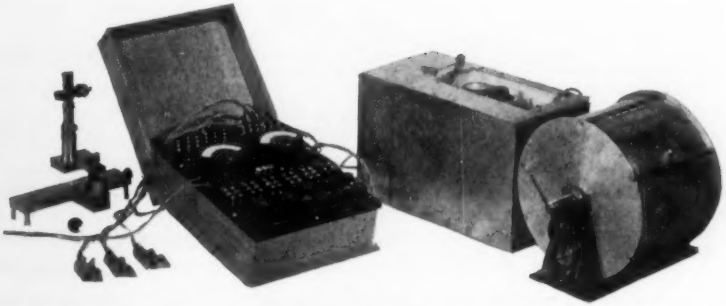


Fig. 352. Telemeter set with special drum camera for high film speed, equipped with high-speed shutter, spiral transverse drive, daylight-loading. At left, a calibrator furnished with all sets, on the slide of which one or two gages may be clamped, their circuits balanced, and measured displacement compared with milliammeter deflection.

PRESSURE AND RECORDING HIGH-FREQUENCY VARIATIONS

Baldwin-Southwark Corp'n)

(b)Piezoelectric

Unexpected difficulties still stand in the way of commercially producing instruments employing the pressure-responsive properties of crystals. A number of such instruments have been made up, chiefly for measuring variations of a rapidity quite beyond any other method, and when used in connection with cathode-ray oscillographs, with or without amplifiers, changes of pressure occuring in the ten-thousandth of a second are not only measured but plotted against time. The principle, as well as the description of one form, are well set forth by J. C. Karcher in Bureau of Standards Scientific Paper No. 445, from which the following is briefly abstracted:

A thin plate with its faces plane and parallel, cut from a quartz crystal so that the plane of the plate is perpendicular to an electric axis of a crystal, when subjected to a compressional force in the direction of the electric axis and normal to the faces, will liberate a quantity of electricity at these faces the magnitude of which is proportional to the force applied. The amount of charge liberated from a perfect crystal is given by P. Curie as 6.32×10^{-8} E. S. U. per dyne or approximately 10^{-11} coulombs per pound for small loads. The published literature does not reveal any data on the relationship between charge and applied force for the large forces to be encountered in this work. Quartz plates were, therefore, subjected to pressures up to 50,000 lbs per sq. in. and the relationship between charge and pressure was found to be linear over the full range of pressures used. The limit of error in these measurements was approximately 0.1 per cent.

A gage may be constructed by using a stack of quartz plates with thin metal electrodes between adjacent plates. In this way more charge is obtained because of the greater plate area. The manner of construction is similar to that of a mica condenser with metal foil electrodes, except that the quartz plates possess polarity and must be so assembled that the faces of the two plates in contact with the same electrode develop charges of the same sign when force is applied. Moreover, quartz, unlike tourmaline, yields no charge when exposed uniformly to hydrostatic pressure so that the stack of plates must be inserted in a gas-tight housing and the pressures must be applied in the direction of the axis of the stack by means of a piston plunger one end of which is in contact with the stack while the other is exposed to the gas pressures to be measured.

The charge $\mathcal{Q}$ developed on the electrodes of such a gage by a pressure P is given by the relation $\mathcal{Q}=cP$ where c is a constant determined by the number and area of the quartz plates, the area of the piston, and some other features of construction. The constant c is readily evaluated experimentally. The validity of this equation for even the most rapidly changing pressures to be encountered by the gage is assumed. Sufficient experimental evidence is available to establish the correctness of this assumption to a high degree of approximation.

If the terminal leads of the gage are connected to a galvanometer through a suitable line, there will be a current

$$i=\frac{dQ}{dt}=c\frac{dP}{dt} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

This current in flowing through the galvanometer will subject the moving system to a torque thereby causing an angular displacement given by the general relation

$$Gi=K\frac{d^2\theta}{dt^2}+D\frac{d\theta}{dt}+U\theta \quad . \quad . \quad . \quad . \quad (2)$$

where G is the dynamic constant of the moving system, K its moment of inertia, D the damping constant, and U the restoring constant of the galvanometer.

If the galvanometer used has a long period and small damping, that is, if U and D are small, it follows from equations (1) and (2) that

$$Gi=Gc\frac{dP}{dt}=K\frac{d^2\theta}{dt^2} \quad . \quad . \quad . \quad . \quad (3)$$

Integrating equation (3)

$$GcP=K\frac{d\theta}{dt}+c' \quad . \quad . \quad . \quad . \quad (4)$$

But $\frac{d\theta}{dt} = O$ when $P = O$. Hence, $c' = O$ and

$$P = \frac{K d\theta}{G c dt} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Equation (5) shows that under the conditions assumed the angular velocity of the galvanometer mirror is proportional to the pressure. The assumed conditions are realized sufficiently well in a high-sensitivity, long-period galvanometer. A photographic record of the galvanometer deflections obtained on a rapidly moving film during the period of pressure change and a simultaneous record of a suitable time scale gives

$$\theta = f(t)$$

The differential of this curve multiplied by a suitable constant is the pressure-time curve.

One form of gage construction (designed for use in the powder chamber of a gun) involves the use of 6 quartz plates arranged condenser fashion. The gas pressure end and the end pressing on the plates are $\frac{5}{8}$ inch and $\frac{3}{4}$ inch in diameter, respectively. The electrodes consist of pieces of platinum foil 0.005 inch thick placed between adjacent plates. The leads were connected to a high sensitivity galvanometer which has a period of 12 seconds, a direct current resistance of 520 ohms, and gives a deflection of 1 mm at a meter's distance for a current of 10^{-10} amperes.

In order to prevent the galvanometer from being disturbed by steady current leaks along the line or by thermal emf's, a 4-mf. condenser was connected in series with the circuit at one of the galvanometer terminals.

(c) Resistance Coil

The General Electric Co. announced in March, 1931, a cartridge type of pressure transmitter with a male thread at one end and cables extending from near the other end. At first sight it appears that this transmitter employs an electrical method of pressure measurement. It does not. The pressure-responsive element is a copper bellows, the expansion and contraction of which moves a short-circuiting rider over a differentially wound wire coil resistance. Electricity is thus employed only to transmit to a remote reading instrument the indication of the measuring bellows which is enclosed, together with the coil, etc., in a weather-proof cartridge suitable for aircraft use—the application for which this instrument was designed.

18. Special High-vacuum Instruments

This heading is employed to avoid confusion. The correct designation for these instruments is low-pressure manometers and gages. In general, however, among production men and in most branches of engineering, "low-pressures" means pressures thousands of times higher than those for the measurement of which the instruments we now take up are designed.

The author acknowledges with gratitude his indebtedness to Dr. Saul Dushman of the General Electric Company for much of the information herein re-told. The courtesy of *The Journal of the Franklin Institute*, in permitting the author to abstract a paper of Dr. Dushman which is to appear later in that publication, is also appreciated.

The incandescent-filament light industry has celebrated its golden jubilee; the several electronic-tube, photoelectric cell and x-ray industries are younger but already gigantic when taken together. The measurement and control of absolute pressures too low for the instruments described in the foregoing sections is thus today of industrial as well as scientific interest. This high-vacuum field extends from about 1 mm (or 1000 microns) of mercury down to vacua so nearly perfect that you can almost count the molecules. The unit most commonly used is the micron of mercury, though some scientific writers report their measurements in dynes per sq. cm.

Between this high-vacuum field and the measurement of "inches of vacuum" as in power plant work, there is a restricted intermediate field represented in some industrial drying processes and calling for measurements from about 10 microns to about 10 mm abs. Discussed by Hickman [53*] together with interesting special gages of his own design.

*Upper figures refer to bibliography at the end of this section.

At the time of writing (1931) the majority of high-vacuum instruments are not generally considered "industrial," hence the designation "special," but some of the newer gages have been made up in continuous-reading or even in recording models, have been installed on continuous process applications and are being placed at the disposal of practical plant men who are not laboratory technicians. When such models are produced in quantities they will have definitely passed from the laboratory to the plant. An outline of high-vacuum measurement, therefore, is not too premature to be out of place, but it must be brief. Extended treatments of the subject are listed in a bibliography at the end of this section. Dushman is not only the outstanding and most informative authority but he writes from the practical American viewpoint.

(a) Classification

A complete list of the methods and instruments is of no engineering interest. Only a few have survived the test of practical usefulness.

(1) Reference may first be made to what might be called the medium-vacuum gages. Most micromanometers, such as dealt with in Section 5, (or in Hickman's article, *loc. cit.*) can be used for such vacuum work, provided as a rule that a known low pressure be maintained on one side instead of atmospheric pressure. This is true, of course, of any short-range pressure-measuring instrument regardless of what class it belongs to. It must not be forgotten in this connection that the torricellian vacuum is a space entirely filled with mercury vapor, which has a pressure of about one micron at room temperature. This mentioned, we can pass on to the special high-vacuum instruments.

(2) *The McLeod Gage*, a form of the compression manometer, is the most widely used. It gives excellent results when well made and properly used, but is rendered useless by traces of condensable vapors, and the unavoidable presence of mercury vapor also frequently affects its accuracy. For this reason among others, McLeod gages are on the whole more useful in the "intermediate" field than in that of really high vacua.

(3) *Hot Wire Gages* are electrical and therefore can be made to furnish continuous records: (3A) *Resistance Gages* employ the principle of the variation of thermal conductivity of a gas with its absolute pressure and measure the resistance of the wire. (3B) *Pyrometric Gages* measure the temperature of the hot wire, which varies with its resistance, with the conductivity and hence with the pressure, when the voltage is kept constant A tiny thermocouple is placed in contact with the filament.

(4) *Ionization Gages* measure the ionization produced in the low-pressure gas by an electron current. They are built like electronic tubes and the richness of experience in this field of design and manufacture has resulted in excellent practical instruments. With amplifiers, industrial electrical recorders can be hooked up.

(5) *Radiometer Gages* utilize the fact that there are only insignificant "convection effects" in a low-pressure gas-filled space, so that a presssure differential is created by a difference in the temperatures of two parallel plates. One plate is a light foil and its deflection by reason of more intense molecular bombardment on the side facing the hotter plate, is a measure of the molecule count when its temperature and that of the opposed surface

are known. No recording gages reported built. Instruments delicate and difficult to calibrate and operate.

(6) *Torsion Fibre Gages* make use of the fact that the damping capacity of a gas varies inversely as the pressure. Very delicate. Require vibrationless mounting. Each reading takes a long time.

(7) *Viscosity Manometers*; (8) *Contact-resistance Gages* and (9) so-called *Molecular Gages*. Same criticism applies. All delicate laboratory instruments. No attempt at industrialization reported.

(b) McLeod Gages

For several decades these compression manometers have been the outstanding instruments for vacuum measurement in the region from about 2 mm of mercury down to about 1 micron.[3] Recent improved models *can* give trustworthy readings down to 0.01 micron or less, but only for vapor-free gases which obey Boyle's Law and do not affect the mercury surface—and then only in competent hands because mercury troubles are difficult to overcome.[46,50]

Accuracy does not depend on the principle but on the design and construction, the measured gas, and the purity of mercury and cleanliness of glass.[53] Sensitivity is determined by the design, the construction and also by surface-tension errors which in given diameters vary according to the condition of the mercury and glass. Both accuracy and sensitivity also depend on the order of the measured pressure, because the principal causes of inaccuracy and of sluggishness and sticking grow more serious as one attempts to measure lower pressures. For all these reasons the author believes that the expectable percent error of individual readings of the "average" McLeod gage under "average" conditions increases as the square of the decimal order starting at 1 mm. That is to say for 1 mm, 1%; for 0.001 mm or 1 micron, 3×3 or 9%; for 10^{-6} mm, 36%. Nevertheless, carefully standardized McLeod gages are used for calibrating various other high-vacuum gages, by expert operators, of course.

The following descriptions, etc., are abstracted from Dunoyer's and Dushman's books[46,50] and from manufacturers' literature:

Fig. 353 is a schematic diagram of the classical form of the McLeod gage. It consists of a bulb *B* with a narrow tube *C* at the top, and joined at *A* to the vacuum apparatus when the mercury level is at *F*. The volume *V* is the volume of the bulb, together with that of *C*, which is cut off when the mercury reaches *A*, while *v* is the volume between the top of *C* and a graduation on the tube. When the mercury is raised until the level reaches this graduation in *C*, it will rise to a higher level in *D*, and if *C* and *D* have the same diameter, the difference of level *h* measures the pressure of the compressed gas so long as the initial pressure is very small compared with *h*—that is, so long as the ratio V/v is large enough. This approximation is evidently valid, since the ratio V/v can be made 100 or 1000 or more. The pressure *h* will then be made 100 times greater than *x*.

For raising and lowering the mercury, the arrangements shown in Figs. 353 and 354 are the ones most employed (but see also the Cenco plunger arrangement, Fig. 358). In the first, the reservoir *G*, containing the mercury, is joined to the gage by a flexible rubber tube, and the level of the mercury is changed by raising or lowering *G*. In the second arrangment the reservoir *G* is fused on to the gage, and it has a small side tube *E* through

Fig. 353

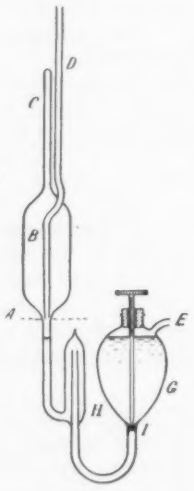


Fig. 354

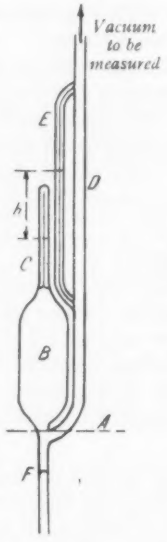


Fig. 355

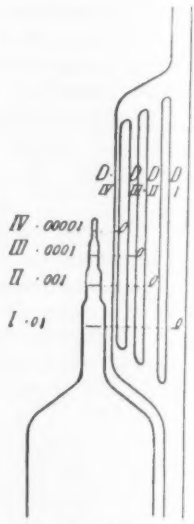


Fig. 356

which the bulb G can either be exhausted or connected with the atmosphere. Between the reservoir and the gage there is a needle valve. When this valve is opened and *E* opened to the atmosphere, the mercury rises in the gage. The rising is stopped by closing the valve when the mercury level reaches the graduation on C. The mercury level is lowered by evacuating G through *E* and opening the valve.

The first arrangement makes the operation a little quicker, and with it there is little danger of mercury getting into the tube system. With the second arrangement, if the valve is not closed in time, G will be emptied of mercury and an inrush of air will follow and may cause breakage.

In spite of this inconvenience the second arrangement is to be recommended for gages used to measure very low pressures, because of the weight of mercury which is then required. If a rubber tube is used, it must, of course, be thoroughly cleaned. See Chapter X, Section 10.

Whatever arrangement is adopted for moving the mercury, it should pass through an air trap *H* to get rid of air bubbles which are carried along with the mercury. The mercury must be very pure. Before it is introduced into the air trap and gage, these should be evacuated and heated to as high a temperature as possible to get rid of gas adsorbed in the walls.

It will be noticed that the design of the bulb in Fig. 354 is slightly different from that of Fig. 353. The idea is to make the volume *V* more definite. In the design of Fig. 353, *V* is the volume cut off by the mercury when the level just closes the opening of *D*. Fig. 355 shows an arrangement like that of Fig. 354 but designed for high sensitivity.

If the compression chamber has the same diameter throughout, the range of the gage is very limited. In practice, with a capillary of 0.8 mm diameter, the maximum length of the compression chamber is 20 cm. If this is exceeded the gage is cumbersome and fragile.[50] If the tube *E* (Fig. 355) is

40 cm long, the gage will measure pressures between 0.01 micron and 160 microns (0.4 micron for 1 mm difference of level). It would seem that too long a capillary would not allow for equalization of pressure between the bulb and the capillary. However, Dunoyer shows that if the diameter of the capillary is greater than 0.5 mm, the equalization is very rapid on account of the small volume of the compression chamber.

This limitation of range can be got rid of by making the compression chamber into a series of capillaries of decreasing diameter joined together. This is shown in Fig. 356. The sizes are so arranged that the marks will be far enough from the joints, so that the diameters at the marks will not be affected when the joints are made. The greater length of the widest tube will, if the sensitivity is 0.01 micron and the length of E is 40 cm, enable the gage to be used for pressures up to 4 mm, and so reach the lower limit of the usual manometers. The difficulty of this arrangement is that the surface tension corrections are different for the different marks. This may be avoided, although it rather complicates the design, by setting up a number of tubes of corresponding diameters parallel to the compression chamber, as shown in Fig. 356, the second set being joined to the vacuum system. Each tube of this set has a mark level with the mark in its corresponding portion of the compression chamber. "There is thus no need," comments Dunoyer[50] on this arrangement, "to apply a surface tension correction, and readings are made directly in the various fractions of 1 mm of mercury." (But see Hickman's edifying paper on mercury surface-tension phenomena in glass tubes, in the *Review of Scientific Instruments*, October 1929).

So much for the principle of the McLeod gage and the problems involved both in design and in use. Coming now to the construction of actual commercial instruments, it is noted that various interesting methods have been employed to solve most of these problems.

Figs. 357 and 358 show the Cenco design, and Fig. 360 shows the G-E gage, which both embody an improved method of elevating the mercury in the measuring head, by pressing down a plunger in the mercury reservoir. In the Cenco design, "The upper end of the plunger is threaded . . . This provides micrometer adjustment for the mercury in the measuring head," Fig. 359 shows the "Improved Columbia University Modification" which dispenses with the glass tube below the measuring head and with the original rubber tube and mercury reservoir sketched in Fig. 353, and employs instead the preferable method sketched in Fig. 354. Modern quick-reading scales, plural-range arrangements, and other features, speak for themselves if one examines closely the illustrations of these three gages.

One problem not yet solved to the point of commercial production is that of providing records. This would involve replacing manual operation by automatic devices; replacing visual leveling by an automatic photo-electric device; and replacing visual reading by a recording device dependent on the visible (to an "electric eye") head of mercury in tube D above the column in tube C. Such industrial compression manometers are bound to appear on the market. There is nothing to "invent" and the difficulties correspond to those that were involved in transforming the hand Orsat gas-analysis apparatus into the new familiar fully automatic power plant instrument that makes one chemical determination per minute and writes the result on a chart.

TABLE XVIII—RANGES OF PRINCIPAL INDUSTRIAL PRESSURE MEASURING INSTRUMENTS

(Prepared for this Handbook by a prominent East Central States instrument company)

Division	Type	Indicating or Recording	Static or Differential	Low Pressure Approximate Maximum Range	High Pressure Approximate Max. Differential Range
Dead Weight	Remote-reading	Both	Static	Short reading ranges by suppression of large part of working ranges to 2500 lb gage	
Liquid Head					
Water	U-tube				
	(a) Vertical	Indicating	Static	0-100″ H_2O	.....
	(a) Vertical	Indicating	Differential	0-100″ H_2O	.....
	(b) Inclined	Indicating	Static	0-10″ H_2O	.....
	(b) Inclined	Indicating	Differential	0-10″ H_2O	.....
Mercury	U-tube				
	(a) Vertical	Both (Float)	Static	0-100″ Hg.	.....
	(a) Vertical	Both (Float)	Differential	0-100″ Hg.	0-50″ Hg.*
	(b) Inclined	Indicating	Static	0-10″ Hg.	.....
	(b) Inclined	Indicating	Differential	0-10″ Hg.	0-50″ Hg.*
Manometer					
Water	Vertical	Indicating	Static	0-100″ H_2O	.....
	Vertical	Indicating	Differential	0-100″ H_2O	0-50″ H_2O*
Mercury	Vertical	Indicating	Static	0-100″ Hg.	.....
	Vertical	Indicating	Differential	0-100″ Hg.	0-50″ Hg.*
	Vertical	Both (electric)	Static	0-40′ H_2O	.....
	Vertical	Both (electric)	Differential	0-25″ Hg.	0-25″ Hg.†
Bourdon Tube	Spiral	Indicating	Static	0-5000 lb gage	.....
	Helix	Both	Static	0-1500 lb gage	.....
Inverted Bell					
(Pendulum counter balance)	Oil sealed	Both	Static	0-10″ H_2O	.....
	Oil sealed	Both	Differential	0-10″ H_2O	.....
	Mercury sealed	Both	Static	0-30″ Hg.	.....
	Mercury sealed	Both	Differential	0-30″ Hg.	.....
Bellows					
(Wt. balanced)	Membrane	Indicating	Static	0-100″ H_2O	.....
	Leather	Indicating	Differential	0-50″ H_2O	.....
	Metal (sylphon)	Indicating	Static	0-3 lb gage	.....

*Differential pressure measurable up to 500 lb static pressure limit.
†Differential pressure measurable up to 1350 lb static pressure limit.

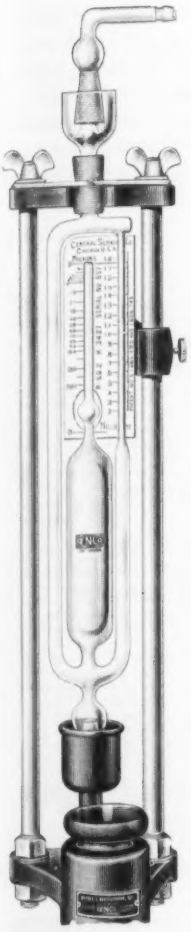


Fig. 357. Close-up of the measuring head of Cenco vacuum gage.

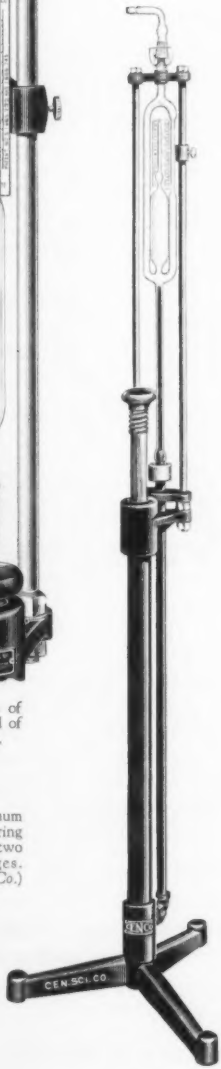


Fig. 358. High-vacuum gage for measuring pressures through two overlapping ranges. (*Central Scientific Co.*)

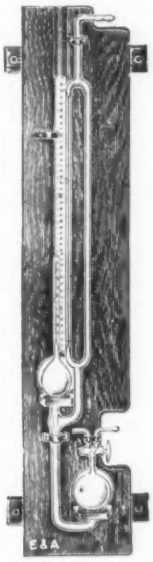


Fig. 359. The "Columbia University" McLeod gage. Compression ratio is 10,000. (*Eimer & Amend*).

Fig. 360. Steel framed high-vacuum gage with metal scale, mercury overflow chamber and other convenient features. (*General Electric Co.*)

TYPICAL COMMERCIAL FORMS OF McLEOD GAGES

*Differential pressure measurable up to 500 lb static pressure limit.
†Differential pressure measurable up to 1350 lb static pressure limit.

(c) Hot Wire Gages

As briefly stated above under Classification, these gages employ the conductivity of the gas which varies with the pressure. This requires a word of explanation in view of the general knowledge of the fact that neither the thermal conductivity nor the viscosity of a gas depend on its pressure *under ordinary conditions*. High-vacuum conditions are extraordinary in that gas molecules travel back and forth between the walls of an enclosure such as a vacuum tube without colliding with one another. (The probabil-

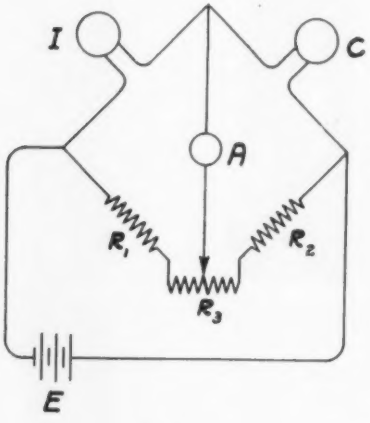


Fig. 361

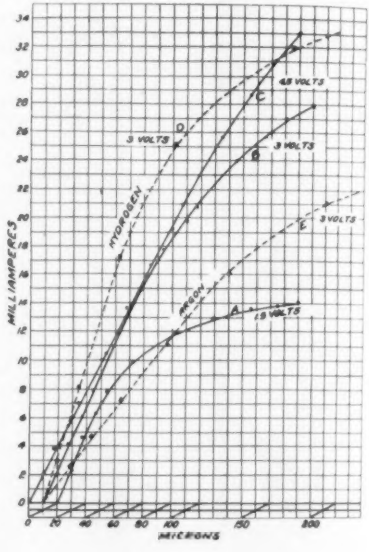


Fig. 362

ity ratio in a two-inch tube is so nearly zero as to be negligible). Heat is conducted to the wall from the filament by every molecule that strikes the filament, for it will next strike the wall. The energy loss from the wire thus varies with the number of molecules—as does the pressure. If the pressure is halved, the energy loss through conductivity will be halved, and since the wire is heated electrically, resistance measurement becomes a simple and reliable matter, any one of three methods being applicable.[8]

(1) The filament is maintained at constant voltage, and the change in current measured as function of pressure.

(2) The resistance, and consequently the temperature, of the filament is kept constant and the change in total watts measured as function of pressure.

(3) At constant current the change in resistance is a measure of the pressure. This method gives the greatest sensitivity.

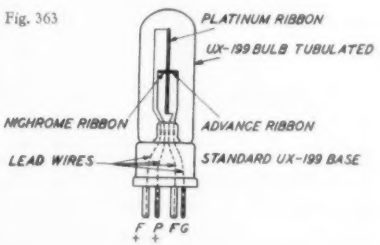
In using a hot wire resistance gage a similar tube which has been well exhausted and sealed off at extremely low pressure is used as a compensator for variations in the surrounding air temperature.

Instead of measuring change of resistance, the change in the temperature of the wire may be measured by placing a tiny thermo-couple in contact with it. Hot wire gages employing the above-mentioned three methods are known as resistance gages; those employing thermo-couples may be called pyrometric or thermocouple gages.

Many forms of hot wire gages have been developed.[8,14,15,16,23,28,40,43,50,52,54] Two recently developed and described by Dushman[56] seem to be classifiable as industrial instruments and deserve description here. The first is a resistance gage, the second a pyrometric gage:

A simple form of direct-reading gage developed at the G-E research laboratory by H. C. Thompson and E. F. Hennelly has proved very convenient in practice. The measuring tube and compensator each consist of a glass tube 1″ diameter and approximately 3″ long in which four, or more, standard 25-watt, 115-volt tungsten filament coils are welded to supports, the total resistance being about 15 ohms at room temperature. The indicating tube, *I*, and compensator, *C*, are inserted in the two arms of a Wheatstone bridge as shown in Fig. 361, while the other two arms consist of two resistances R_1 and R_2 (about 14 ohms each) and a resistance R_3 (about 2 ohms) which can be adjusted to obtain zero current in the ammeter *A*. A dry cell battery supplies the constant source of potential. Fig. 362 shows plots of current (in milliamps) versus pressure in microns for a typical outfit (10^{-3} mm). In order to prevent confusion three pressure scales have been used, as shown. Curves *A*, *B*, and *C* refer to dry air at three different

Fig. 363



battery voltages, while curves *D* and *E* refer to hydrogen and argon respectively. It will be observed that for pressures below about 40 microns, the plots are linear and practically independent of battery voltage. By use of a sensitive milliammeter and care in construction of the tube and compensator, pressures as low as 10^{-6} mm may be measured. Using a relatively cheap type of indicating instrument, the limit is between 10^{-5} and 10^{-4} mm.

A pyrometric gage recently developed in the G-E Research Laboratory by Dr. N. T. Gordon consists (Fig. 363) of a platinum iridium ribbon 0.00064 cm. × 0.0225 cm., to the center of which is welded a nichrome-advance ribbon thermocouple (0.00125 cm. × 0.01 cm.), all mounted on a four-lead stem, in a tubular bulb similar to that used for the UX-199 radiotron. A constant current of approximately 30 milliamps is passed through the platinum ribbon and the temperature measured by means of the couple. Three dry cells in series, with a fixed resistance of about 110 ohms (of very low temperature coefficient) and a variable resistance of 40 ohms, supply the current, which is read on a milliammeter, while a sensitive millivoltmeter of standard type is used to read the thermocouple emf.

TABLE XIX—INDUSTRIAL PRESSURE MEASURING INSTRUMENTS—RECAPITULATION

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CLASS	TYPE	CHARACTERISTICS (Notes below table explain symbols)		
		Optimum Range*	Accuracy	Other Characteristics
U-tube	Glass—mercury	0.5-24″ Hg	0.5%	Ga Di *Co* **In** *Sd* **Sy** Vb
	Glass—water	0.5-24″ H_2O	0.5%	Ga Di **In Sy** Vb
	Glass—two-liquid	0.01-1″ H_2O	0.5%	Ga Di Dr **In Sy**
	Float, electric, etc.	0.5-15″Hg	1%	*Ga* Di Co Ex Re RR Sy Vb
	Multiple-tube	10-100′Hg	0.5%	*Abs* Ga Ex **In** Sd **Sy**
Single tube	Vertical—open top	2-30″Hg	1%	**Ga In** Ru Sy Vb
	Compression manom.	vac.-200 lb.	1%	Abs *OV* **In** Sy
	Open-cistern vac. gage	2-18″vac	0.7%	Abs OV **In** *Sd*
	Mercurial barometer	Atmospheric	0.2%	**In** *Sd*
	Abs. pressure gage	2-12″Hg.abs	0.7%	Abs. OV **In** Sy
	Inclined-tube	0.1-2″ H_2O	1.5%	Ga OV Dr **In Sy**
Micromanometer	Null method, etc.	.01-10mmHg	0.05%	Ga OV **In Ex Sy**
Liquid col. & plunger	"Pneumercator"	50-5000 lb		Ga **In** Ex Ru
Weight-loaded piston	Dead weight	20-8000 lb	0.1%	**Ga In** Ex Ru Sd
	Fluid pressure scale	50-8000 lb	0.2%	**Ga In** Ex Ru Sd
	Pendulum	100-8000 lb	0.2%	**Ga** *Co* Ex *Sd*
	"Cup" (Bailey)	200-1000 lb		**Ga** *Co* Ex Re **RR**
Inverted bell	Oil sealed	0.1-10″ H_2O	1%	Ga Dr *Di Co* Re Sy
	Mercury sealed	0.1-10″Hg	1%	Ga Dr *Di Co* Re Sy
Tilting	Ring, etc.	0.1-10″Hg	2%	Ga Dr Di Ex Re RR Sy
Tube-spring	Single Bourdon	10-5000 lb	2%	Ga OV *Co Re RR* **Ru** Vb
	do. "Inspector's"	10-5000 lb	0.5%	Ga Ex **In** Sd
	Double Bourdon	50-800 lb	2%	**Ga Ru** Vb *Co* Ex
	Helical	5-500 lb	1.5%	**Ga** *Co* Ex Re *RR* **Ru**
	Spiral	10-1000 lb	1.5%	**Ga** *Co* Ex Re **Ru**
Diaphragm (Metallic)	Unloaded, flat	1-100 lb	2%	Ga OV *Co* Re Ru *Va Vb*
	Unloaded, corrugated	0.5-50 lb	3%	Ga OV Dr Co Re *Va*
	Spring-loaded	2-200 lb	2%	Ga OV *Co Ex* Re Ru *Va*
Bellows	Unloaded	1-100″ H_2O	2%	Ga OV Dr Di Co Re *RR* Sy
	Spring-loaded	0.5-30 lb	2%	Ga OV Dr *Co* Ex Re *RR*
	Pendulum-loaded	10-200″ H_2O	2%	Ga OV Dr *Co* Ex Re Sy
Membrane (leather)	Spring-loaded	0.2-50″ H_2O	1.5%	Ga Dr Di *Co* Ex Re Sy
Capsular spring	Unloaded	1-50″ H_2O	3%	*Abs* Ga OV *Di* Ru *Va* Vb
	Aux. spr. loaded	0.5-10 lb	2%	*Abs* Ga OV *Di* Ru *Va*
	Null method	Atmospheric	0.1%	Ex **In**
	Aneroid barometer	Atmospheric	0.2%	Re
Electrical	Carbon pile	50-2000 lb	2%	**Ga** Ex **Os** Re RR Ru **Vb**
	Crystals	100-20000 lb	2%	**Ga** Ex **Os** Re **Vb**
High-vacuum	McLeod	0.01-1000 μ		**Abs In** Sd
	Hot wire—resistance	0.01-1 μ		**Abs** Re
	do.—pyrometric	0.001-1 μ		**Abs** Re
	Ionization	0.0001-0.1 μ		**Abs** Re Va

*Not scale range but limits between which the type is preferably employed.

Bold-face type signifies that remark applies to **ALL** instruments of this type. *Italics* signify that remark applies only to *SOME* instruments of this type. Symbols in plain roman type apply to majority of instruments.

Abs. Suitable for measurement of absolute pressure.

Ga. Preferably used for measurement of gage pressure (above atmospheric).

OV. Suitable for measuring ordinary vacuum (negative pressure below atmospheric).

Dr. ditto, especially for draft.

Di. Suitable for measuring differential head, as in flow measurement.

Co. Contact arrangements available for signalling, etc.

Ex. Necessarily expensive, compared with other types **for same range.**

In. Indicating only—No recorders on market.

Os. Can actuate oscillograph for study of extremely rapid fluctuations.

Re. Recording models available.

RR. Remote-reading systems regularly made up.

Ru. Rugged construction of pressure-sensitive element.

Sd. Suitable for use as **Plant Standards.**

Sy. For steady pressures only. (opposite of Os.)

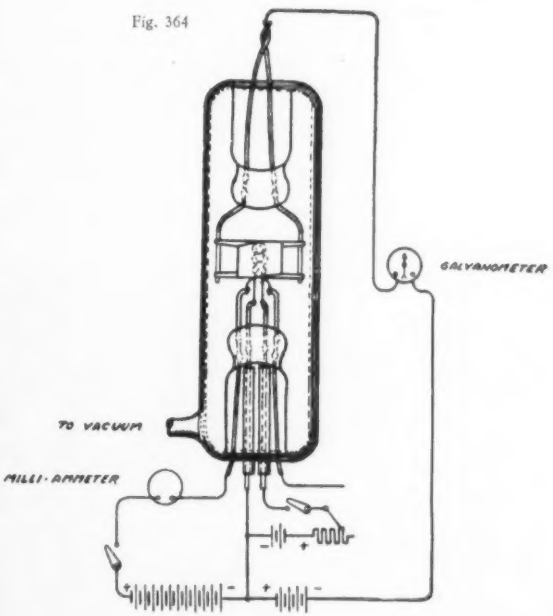
Va. Suitable for exact measurement of moderately variable and fluctuating pressures

Vb. Withstand severe vibrations.

(d) Ionization Gages

The most satisfactory method for pressures below 0.1 micron is that involving measurement of the ionization produced in the gas by a definite electron current.[56] The electrons emitted from a tungsten or oxide coated filament, are accelerated by applying a positive potential varying between 100 and 250 volts to an adjacent electrode (the anode), and the positive ions resulting from collisions between electrons and gas molecules are collected by a third electrode which is maintained at a negative potential (10 to 50 volts) with respect to the cathode. Buckley,[29] and Dushman and Found[44,48] have developed this method. These latter's gage (Fig. 364) consists of two

Fig. 364



helically wound tungsten spirals, of which the inner is used as cathode and the outer as anode, while the molybdenum cylinder surrounding these spirals is used as collector of positive ions. For a given electron current (1 to 20 m.a.) and constant anode voltage (100 to 250 volts) the ionization current is observed to be proportional to the pressure, while over a considerable range of electron currents (1 to 20 m.a.) the ionization varies linearly with the electron current. With this gage the lower limit of pressure is determined by the sensitivity of the instrument used for measuring positive ion current, and by electrical leakage between collector and filament, which leakage is largely eliminated by using the two-stem construction shown in Fig. 364. With a galvanometer indicating 10^{-7} amp. and 10 milliamp electron it is possible to read pressures as low as 10^{-8} mm. (10^{-5} micron). For pressures of the order of 10^{-3} microns or higher, a regular type of three-electrode vacuum tube may be used, and observations with gages of this form[43] show the same proportionality of ionization current with electron current and pressure. It is essential before using this gage to denude metal

parts of gas. Since the oxide coated cathode is much less liable to injury by accidental inrush of air, it is often preferred for use in ionization gages.

For very great sensitivity the positive ion current may be amplified by use of a push-pull amplifier circuit.[51] Also the positive ion current may be used to charge up a condenser and the potential of the latter is then measured by connecting it to the grid of an amplifier.

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CORRECTIONS

In Chapter X, Section 4, the statement that "it is impracticable" to transmit mechanically to a pointer or pen the motion of a float in a differential gage built to withstand static line pressure of over 2000 lb per sq. in. should, of course, have read "it is difficult." THE FOXBORO COMPANY'S friction-less float spindle packing, in fact, stands up under 5000 lb per sq. in.

In Chapter XI, Section 11, stronger emphasis should have been laid on the ability of *restrained diaphragms* to withstand overloads. THE ROCHESTER MANUFACTURING COMPANY'S 0 to 4 lb gage shown in Fig. 309 (page 152) can stand 150 lb without overstressing the diaphragm.

THE MERIAM COMPANY should have been credited under Figures 338 and 339 on page 170 of the March issue. These two illustrations represent the *Meriam Pulsation Absorber*.

NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

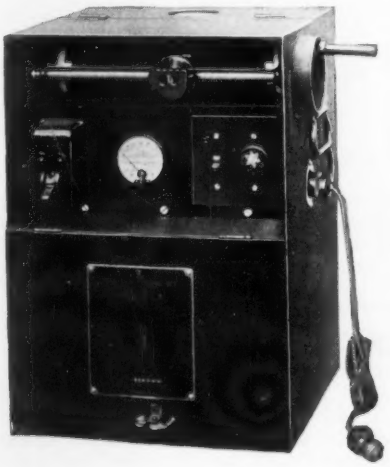
Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional Information

Portable Equipment for Testing Oil

(American Transformer Co.)

IT is common practice for the maintenance men of a public-utility company to remove samples of oil from transormer equipment in the field and take these to the laboratory for testing. This is considered advisable in many cases because complete laboratory equipment has been too bulky to carry in an ordinary automobile and because small-sized testing sets have proved inadequate. On the other hand, there are many objections to this system, such as loss of time, danger of mixing samples, and the possibility of foreign matter being mixed with the oil.

This apparatus just placed on the market eliminates the necessity of the inefficient method described above. It is an oil test set providing all the advantages of a laboratory but of such size that it may be placed in any passenger car and taken into the field.



The new AmerTran oil tester is completely housed in a rugged sheet-steel case of welded construction which may be shipped without further crating. It operates from standard 110-volt, 60-cycle power lines and employs a 30-kv. testing transformer with a rating of 0.5 kva. Other standard equipment includes circuit breaker, accurate voltmeter, wire-wound potentiometer, bakelite oil cup, pilot light, and detachable connection cord. The weight of the set has been reduced to 120 lb. and the overall dimensions are 13″x14½″x18¾″.

Two new features which never before have been included in portable equipment for oil testing are found in this instrument. The first is a safety device making it impossible to come in contact with high-voltage parts while the set is in operation; the second permits more precise results by providing a means for increasing the test voltage from zero to maximum at a rate of approximately 3 kv. per second.

Absolute safety has been insured by completely enclosing all high-potential wires and by locating the oil cup in a compartment equipped with a switch which functions to open the power circuit when the lid is raised. The cover to this compartment is also fitted with a glass window to allow visual inspection of oil during a test.

The improved voltage regulator consists of a collaps ble crank mounted on the outside of the case and coupled to the potentiometer slider through a worm gear. This makes possible the smooth increase in voltage which is essential for accurate results.

Operation of the test is simplicity itself. It is first necessary to clean the oil cup and adjust its 1″ disc electrodes to a distance of 0.100″ apart with the gage supplied. Then the cup is filled with the sample to be tested, the power is turned on, and the voltage is advanced from zero until breakdown occurs. At the instant of breakdown the dielectric strength of the oil is indicated on the voltmeter; also the circuit breaker opens the primary circuit, thus protecting the equipment against overload.

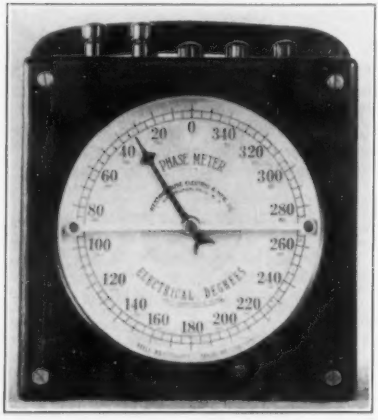
Portable Phase Indicator

*By Paul MacGahan**

IN the application of apparatus having both current and voltage windings, the proper connection to polyphase circuits involves the necessity of knowing the phase relations of different line currents and the different voltages.

Often the connections cannot be traced out to their source due to the use of conduits or too complicated wiring.

In tracing out or determining proper connections, it is a case of either determining the phase relation of one voltage to another or the phase relation of a current circuit to a voltage circuit.



The latter is by far the more important condition when it comes to connecting up instruments or relays.

In order to test out the phase relations between any given current and voltage, an ordinary indicating wattmeter may be used or else an ordinary indicating power factor meter.

Such instruments however, have the great disadvantage that their scales extend over an arc of perhaps only 90° or 100° according to the construction and as the phase relations may vary throughout the complete range of 360° the connections of the instruments must be changed in various ways to bring the readings of the pointer on the scale thereby introducing uncertainty or confusion.

The phase meter however, has a dial forming a complete circle or 360° and the pointer is free to assume any position without the restraint of a spring or any movable coils or connections.

In operating principle however, the phase meter is nothing but an ordinary single phase power factor meter. It will be remembered that power factor meters are merely phase direction meters, the scales of which are graduated according to the cosine of the angle of lag or lead. A phase meter therefore differs from a power factor meter in that its scale is marked off only in angles of lag or lead instead of in cosines of such angles.

Therefore an ordinary single phase power factor meter could be used as a phase meter except that when designed as an accurate power factor meter, the moving coil dynamometer principle is used and this restricts the scale angle mechanically as previously noted to 90 or 100° deflection.

By using a construction in which all the coils are stationary, and a movement having a magnetic iron vane, it is possible to obtain the complete 360° scale as necessary for determining the phase angle of various connections. This construction is the same as that found in the Westinghouse rotating synchroscope, which instrument is another variation of the phase meter principle. In the synchroscope the object is to indicate the variations of phase angle between different voltage circuits derived respectively from a bus bar and an incoming machine. Therefore all the coils of the synchroscope are wound for voltage and the scale is marked only at one point corresponding to synchronism.

The phase meter, however, has one of its coils wound for current and the other coils wound for voltage. The current coil is generally wound for 5 amp. for use in the secondary circuits of current transformers and the voltage coil is generally wound for 110 V.

Generally speaking therefore, the phase meter can be used for checking voltage and current vectors on any types of relays and any types of instruments having both current and voltage connections.

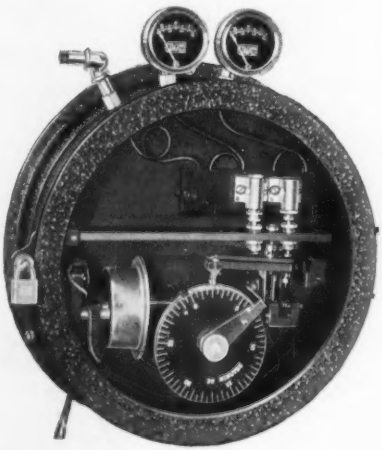
The instrument as manufactured being about 8″ square is somewhat larger and heavier than might be sufficient for the purpose but it has the practical advantage of using the same parts which are made in large quantities for synchroscopes and therefore the cost of the instrument is much lower than would be ordinarily expected for a special device of this character.

*Westinghouse Electric & Manufacturing Company.

New Timer for Individual Vulcanizers

(C. J. Tagliabue Mfg. Co.)

UNTIL recently cycle controllers or timers for individual tube and tire vulcanizers had the cam cut so that it started the cure at the zero mark, went through the complete cycle of operations, and having made a complete revolution, came back to zero at which point the clock was stopped. Obviously the length of cure was definitely fixed by the reduction gearing between the cam and the electric clock whose revolution time could not be altered. Also the timing of events was permanently decided by the contour of the cam. Changes in cure length were accomplished by substituting new gear wheels and changes in intermediate timing by recutting the cam.



Insistent demand for a quick and easy means of adjusting the timers in this respect and one which would not involve buying and waiting for new gears has now been met by the new Tagliabue fully adjustable timer which is constructed in the following manner.

Instead of an electric motor only capable of revolving counter-clockwise, a reversible electric clock is used which revolves counter-clockwise during the first half of the cure, then reverses automatically and turns the cam clockwise back to zero where it again reverses (so as to be ready for the next cure) and immediately stops. In this timer, it is possible to change the cure length in a few seconds' time because it is only necessary to reset the reversing arm at the new time on the cam which is of course graduated in minutes. The reversing mechanism is extremely simple and an endurance run of many thousand repeated cycles testifies to its dependability. To make adjustment complete the period during which the tube is venting has also been made fully adjustable by having a separate cam sector (readily loosened, shifted and relocked) govern this operation. These portions of the compound cam which govern the operation of the closing cylinder, locking cylinder, etc. do not require adjustment as the timing of these operations is always the same regardless of changes in the length of cure.

In this controller, a worm drive is used between clock and cam to eliminate the back lash present in spur gearing. Ball bearings are used not only for the two worm shaft bearings but also for the cam spindle, thus assuring perfect runing at all times. A friction piece makes it possible to move the cam manually should this be desired.

Test Water Cooling Coils

THE sampling of steam and water at various points in the power cycle has come to be a vital necessity in modern power plant operation. Samples are taken:

1. To determine quality of water supply.
2. To control the method of treatment for the prevention of corrosion and scale formation.
3. To control boiler concentration.
4. To minimize wet steam, foaming and priming.
5. To detect and measure condenser leakage.

In order to secure truly representative samples, it is necessary to provide adequate cooling of the hot sample to room temperature while still under pressure. If this is not done, a non-representative sample will be obtained due to the "flashing" of the water samples drawn off. A method of securing representative test water samples is now offered by Bailey Meter Company.

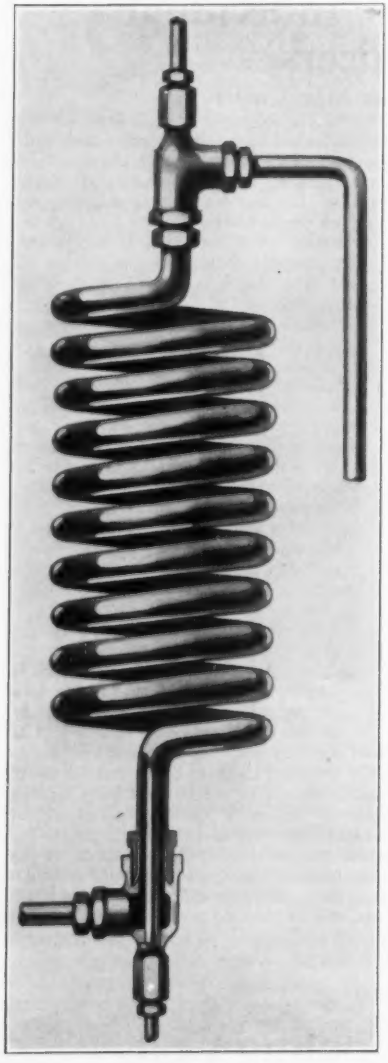


Fig. 1

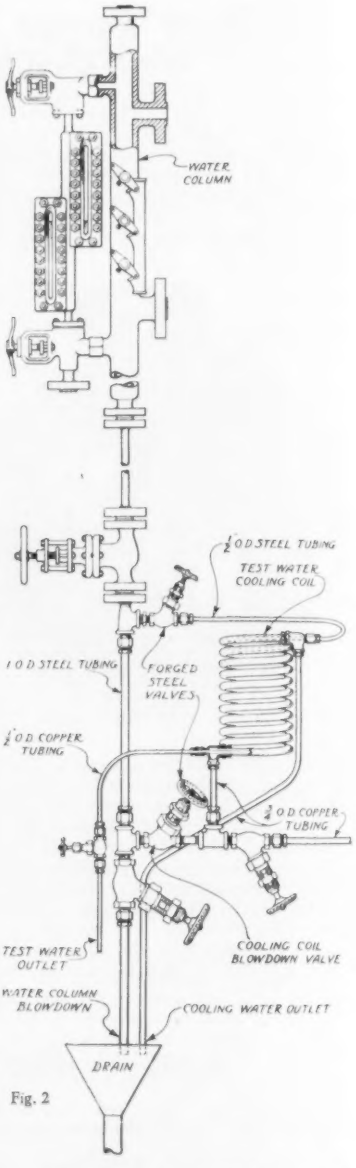


Fig. 2

These coils, which consist of a tube within a tube, as shown in Fig. 1, are made from copper tubing and Dieform compression fittings. In operation the hot test sample enters the smaller inner tube at the top while the cooling water enters the outer tube at the side outlet on the bottom. Cooling water completely surrounds the inner tube as it passes upward through the annular space between the tubes to the side outlet at the top. This type of test water cooling coil performs at maximum efficiency because of the counter flow principle which tends to equalize the rate of heat transfer throughout the entire length of the coil. It also has an added advantage due to the upward flow of cooling water in that a supply of cooling water

always surrounds the inner coil regardless of how slowly water flows through the outer coil.

Dieform test water cooling coils are being used to secure boiler water samples, steam manifold samples, evaporator samples, turbine samples and water samples at boiler feed pumps, feed water storage tanks and purifiers.

The method of installing a Dieform test water cooling coil for obtaining boiler water samples is shown by Fig. 2. The inner tube of the coil is connected to the boiler water column blow down so that samples of test water may be taken from the blow down line and cooled to room temperature before they are released to atmospheric pressure. Samples taken in this manner may be collected in glass bottles at the test water outlet. A valve in the cooling water supply line makes it possible to vary the flow of cooling water through the coil and thereby control the temperature of the test water sample. The rate of flow of test water is controlled by a forged steel valve in the ½ inch O. D. steel tubing which connects the test water cooling coil to the water column blow down.

Most successful results are obtained by drawing test water samples at the rate of approximately one quart per minute and by taking a total sample of approximately one gallon.

Dieform test water cooling coils are designed for working pressures up to 1500 lbs./in.² and may be built specially for higher pressures if desired.

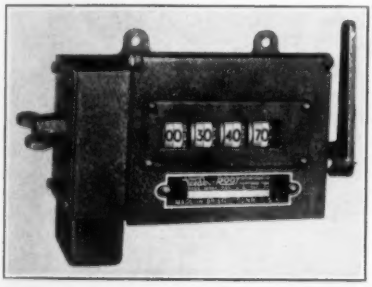
Predetermining Counter

(*Veeder-Root, Inc.*)

THIS counter is one which can be set to any desired number within its capacity and will, when that number is reached, make or break contact in an electric contactor which is part of the counter. The electrical circuit may be used to flash a light, ring a bell, and/or stop the machine upon which counter is installed.

The counter itself has 2 distinct sets of figure wheels, one set having large black figures on white wheels (the counting wheels), the other, small black figures on metal wheels (the predetermining wheels).

The metal wheels are set manually to the desired predetermined number. Upon operation of the counter the counting wheels advance, the predetermining wheels subtract, and when the counting wheels reach the number which was predetermined on the metal wheels the electric contactor operates, making or breaking the electric circuit.



After the contactor has operated, and to set back the counting wheels to zero, it is only necessary to pull out wing nut and turn it once around. The metal wheels automatically return to the predetermined number. The counter is again ready to repeat its previous cycle and will do so until a different number is set on the metal dials.

There are many production machines where this principle will be most desirable, and from the various combinations of installations that can be made, its uses are almost unlimited.

To stop individual motor-driven machines, only very simple wiring to the starter box is necessary. For belt-driven machines an electric stop motion is required in combination with the counter which will shift the belts or operate a clutch as may be required.

The above results may be accomplished in connection with the giving of various audible or visible signals, such as ringing a bell, lighting a light, etc.

The contact is suitable for voltages up to 220 A. C. or D. C. It can be set for either open or closed circuit operation.

The instrument has an additional feature which provides for continuous operation of the alarm, electric light, bell, or stop motion until it has received attention. This feature is of great value, because it insures the alarm receiving attention, prevents the operator from starting on the next cycle of operations without resetting, and, of course, nullifies error caused by forgetfulness.

The standard counter is constructed with shaft on either right or left hand end of counter; to operate as a rotary, rotary ratchet, or ratchet drive instrument, with or without lever stops and return lever spring and with either top-coming or top-going rotation of shaft.

New *Tycos* Compensated Tubing

TO eliminate possible error in the functioning of temperature instruments, due to external temperature conditions surrounding the tubing connecting the bulb to the instrument itself, has long been the endeavor of temperature instrument engineers and designers. Many methods have been attempted but, due to inherent weaknesses of the parts themselves, depending as they did on auxiliary levers of springs, have been unreliable.

The Taylor Instrument Companies have produced a revolutionary type of capillary tubing in which the compensating qualities have been incorporated in the material of the tube itself. No parts are added to the mechanism of the instrument, and no adjustments are necessary during the life of the instrument.

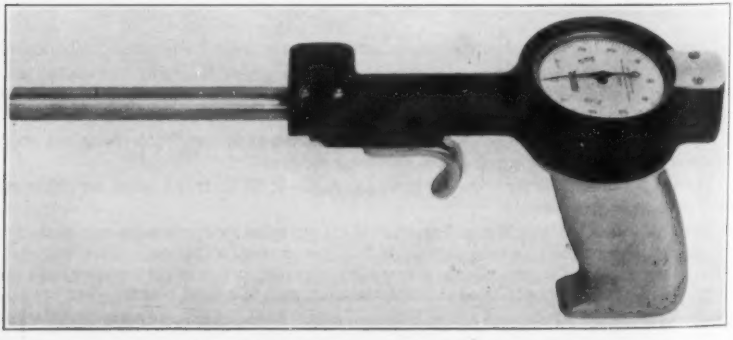
Essentially the new method consists of so proportioning the volume of mercury in the tubing to its coefficient of expansion and to the size of the alloy wire, that any change in the volume of mercury, resulting from external temperature changes, is accurately compensated. For this reason the adjustment is made for each varying exposure, and it is not necessary to compensate the instrument for the *average* external condition along the length of the tubing, a difficult, if not impossible adjustment to make.

To make this new development possible, it has been necessary to devise entirely new methods of producing the steel tubing, and the finished product is controlled with regard to material, physical properties and accuracy of bore, within extremely close limits.

Cylinder Test Gage

(*Federal Products Corporation*)

THIS gage, Model 165, is designed for measuring inside diameters of parts in process from ¼″ up to 1½″. The dial indicator is graduated in 0.0001″. The gaging plug can be changed in less than 30 seconds and the range of each individual plug is + 0.010″. Standard lengths of gaging plugs are ¼″ to ⅜″ — 2¾″. ⅜″ to ⅝″—3¾″. ⅝″ to 1½″—5¼″, but special length gaging plugs can be furnished if desired.



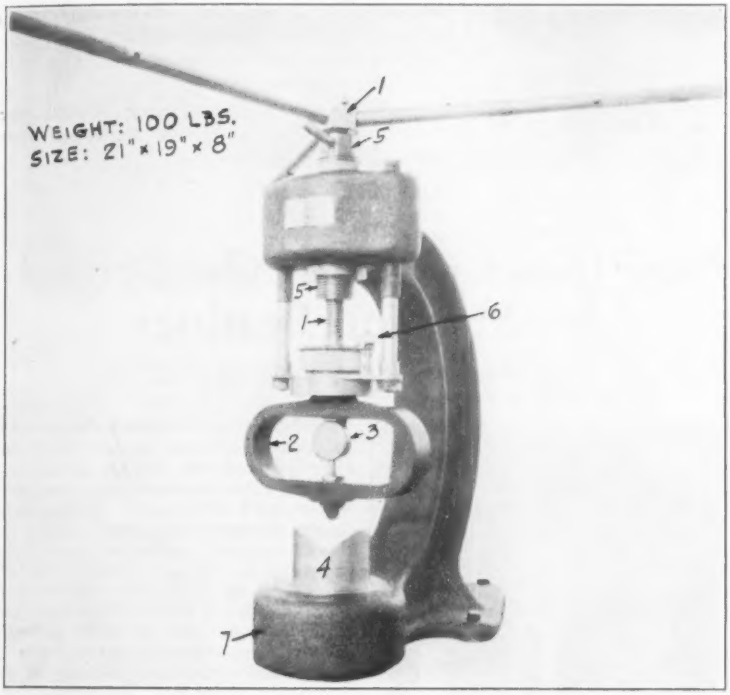
This gage will check inside diameters for size, out of roundness, taper and bell mouth to less than 0.0001″.

Wazau Brinell Hardness Tester

(Southwark Foundry & Machine Co.)

FOR determining the hardness of materials, the Brinell and Rockwell Tests are the most widely used. Both of them can be made with the machine described below. The tester is a simple, reliable and accurate machine for the shop and laboratory and will withstand rough usage without impairing its accuracy.

The load is applied by a hand-driven screw (1) and measured by an elastic precision ring dynamometer (2) and dial (3) which is graduated in 10 kg. divisions. Three revolutions of the pointer represent 3000 kg.



The vertical opening of the press is 4" and can be quickly adjusted to any smaller distance by inserting blocks (4) of different heights. The supporting table (7) is of the overhung type, in order to accommodate ring shaped pieces.

An innovation in this machine is the arrangement of the hollow bronze screw (5) which is rotated automatically when turning the main screw (1) under small loads. At higher loads, the screws disengage automatically, leaving screw (1) to do the final loading. By this construction, the diameter of screw (1) can be kept reasonably small, enabling the easy operation of the machine.

In all cases, the load is easily read on the dial (3). When making the standard Brinell test, the indentation produced is measured by a special instrument furnished with the machine. The diameter of the impression is read in hundredths of a millimeter. The corresponding Brinell number may be taken from any table or hand book.

Recent investigations show the value of measuring the depth, instead of the diameter of the indentation, as is done in the Rockwell test. This measurement can also be taken on the Wazau tester, by observing scale (6), which indicates the vertical movement of spindle (1) in hundredths of a millimeter. The divisions are of sufficient width to permit estimating to fifths, equivalent to 0.002 mm. This is the unit of the original Rockwell dial.

The Rockwell values are obtained by multiplying the readings of scale (6) by five. This measurement is recommended in particular for Brinell tests as a check on the diameter readings.

Redesigned Indicating Pyrometer Control

(Taylor Instrument Companies)

The Tycos indicating pyrometer control has been redesigned to embody new features and several improvements.

The weight of the instrument has been decreased by 3 pounds and it has been shown to be unusually quiet in operation. The back panel has been eliminated, which simplifies wiring and makes the instrument easier to install, or take down.

Simplicity of design and total absence of vibration or shock of any kind in the operating mechanism insure dependability and long life.

New Constant Level Oil Control for Machine Bearings

(Daun-Walter Company)

THE device consists essentially of a main reservoir with gage to show the height of oil in reservoir, supporting bracket, threaded lower extension for oil lead connection and a filling cap on the top. It is claimed the device will accomplish what no combination of mechanical movements known can do—replace the exact amount of oil used by the bearing when and as it is used. This is due to the fact that the action of the constant level oil control is based on scientific equalization of natural forces—gravity and atmospheric pressure—hence it cannot fail to operate. The delivery of oil is automatic and constantly controlled without the use of floats, springs or valves, and correct levels are easily and permanently obtained by adjusting the attaching bracket. The constant level oil control prevents losses from faulty or untimely lubrication and eliminates entirely the bothersome and oft neglected question of when to replenish and how much oil to give bearings, for it automatically replaces the amount of oil used—no more— no less.

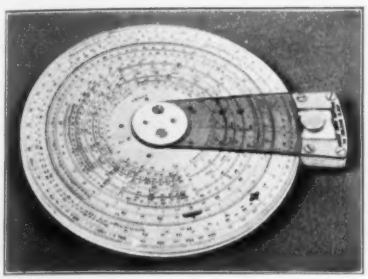
The oil may be piped in any horizontal direction and can feed one or several bearings on the same level; or in connection with a special adjustable wick unit, single or multiple, bearings on different levels can be accurately fed.

The constant level oil control is made with oil reservoir capacities of from ½ to 2 gallons.

New Circular Slide Rule—The Rotarule

(J. R. Dempster)

FIFTY INCH scales on a 5″ diameter rule, and provision for taking up wear between disk and ring, are two of the many features of the new instrument. It is claimed 4-figure accuracy may be obtained even at the "9 end" of the scales and 5 figures may be read by a close interpolation at their lower ends. To obtain this great length on a pocket rule, each of the 50-inch scales is coiled 4 times around the disk. A set of 13″ scales for extremely rapid multiplication and division is also provided. The circular construction eliminates the annoyance of "running off the end" experienced with straight rules when the slide is too far to the right.



The 5″ diameter of the Rotarule permits conveniently carrying it in the coat pocket. It is made of solid white celluloid, thoroughly seasoned, both sides of the instrument being utilized for the scales which are reproduced from engine divided master plates by an etching process which insures permanency. The disk is held accurately concentric with the ring by means of 3 metal shoes which are spaced at intervals of 120° around the bore of the ring and are adjustable by fine-pitch screws extending through the ring to its outer edge. Should wear occur, a very slight turn on the 3 screws will instantly compensate for it. The same device is used to adjust the friction to suit the taste of the individual. The adjusting mechanism is entirely enclosed within the body of the rule, only the countersunk heads of the adjusting screws being visible. The runner pivots releasing a button clamps the runner in place.

All the usual scales are provided including a log-log scale and an inverted scale which makes it possible with one setting to perform any multiplication or division involving 3 factors. The trigonometric scales improve upon those of the ordinary straight rule, for in addition to being 17″ long, they give all 6 functions and are arranged to be extremely simple in operation. Special scales include a pair for solving $\sqrt{x^2 + y^2}$ with one setting, and scales for reducing observations in stadia surveying.

A 3 power magnifier which mounts in the center of the Rotarule, on either side, and turns with the runner arm, and a leather case, are available.

Automatic Recording Revolution Counter

(American Askania Corp.)

THE exact determination of the number of revolutions is fraught with considerable difficulty, even today. The forms of apparatus already on the market are accurate enough so long as merely an approximate indication of the number of revolutions is all that is wanted. Most of instruments work on the ball governor or whirlwind principle. In practical working they have rendered excellent service, but where the exact number of revolutions is required for sale propaganda purposes, they no longer meet the case. Revolution counters with positive coupling have proved more accurate. Instruments of this type have a shaft which actuates the counter mechanism, the latter being stopped by clockwork at very brief intervals. Their design, however, is so complex and the stopping mechanism subjected to such hard wear that breakdowns and inaccurate readings are unavoidable.

The most reliable of all methods of counting revolutions is without question that which involves the direct stopping of the counter mechanism. This, however, requires close attention to make sure that the counter mechanism and the clock are really stopped at the same moment. To obtain the requisite synchronism, so-called "point counters" have been constructed in which the clock and the counter are actuated simultaneously by mechanical means.

Simple though it is, the apparatus likewise has its disadvantages. First it requires a degree of attention such as can hardly be devoted to it when the observer is kept busy reading other instruments or when a heavy strain is placed upon his physical and mental powers, as will often happen when flying at high altitudes.

Furthermore, the simple point counter will not serve the purpose of counting the revolutions of a remote or inaccessible engine during the progress of a flight, nor is it suitable for keeping check on several engines simultaneously.

To overcome these drawbacks, an automatic point revolution recorder has been developed.

The principle of the apparatus is very simple. The counter mechanism is provided with reversed figuring in relief, in front of which is a travelling inking ribbon and behind a strip of paper. A magnet hammer controlled by a contact clock strikes the counter mechanism at any desired intervals and causes the row of figures in position at the moment to be printed off on the paper. In order that the rapidly moving digit figures shall not smudge, there is a device which stops the counter mechanism momentarily during the time occupied by the printing stroke. At the same time a spring is placed under tension, and on its release causes the counter mechanism to jump forward again after the printing is done. As soon as the hammer returns to its original position, the ribbon and the paper continue to travel, The same process is repeated continuously, so that the strip of paper eventually shows a column of figures, the difference of which will be the number of revolutions performed during the time under review. In order to identify periods of time within which the record is of particular importance, time markings can be printed on the strip by means of a supplementary contact device. If it is necessary to record the revolution speed of several engines at the same time, the several counters can be controlled by one contact clock. By this means absolute synchronism, to a degree hitherto unattainable, can be achieved. This is of special value in connection with multi-engined aircraft.

The advantages of an apparatus such as here described will be obvious and are briefly summarized below:

1. The automatic point counter needs no attention beyond setting and turning off the contact clock.
2. The intervals of time between each record can be set at will.
3. The contact clock, as well as the source of current, can be placed at a point quite remote from the actual counter, if desired.
4. The point counter itself can be placed close to the engine of which the performance is to be recorded. (No need for a long flexible shaft with its attendant drawbacks.)
5. One contact clock will control several point counters, ensuring absolute synchronism.
6. The records are produced mechanically, so that the human element of error cannot enter into them. For sale purposes they constitute, therefore, reliable documentary evidence.
7. The records obtained are extremely easy to read and to use.
8. By means of a separate device time markings can be recorded on the band whenever required.

X-Raying steel, iron and metal up to a thickness of 4½ inches is the service rendered to industry by the newly organized Claud S. Gordon Steel X-Ray Laboratory of Chicago. Patterns, tools, dies, castings, raw material and all shapes and sizes of steel and iron will undergo the microscopic scrutiny of this most powerful of all X-Ray equipment. This steel X-Ray Laboratory is the only one of its kind west of New York. The General Electric X-Ray Corporation of Chicago furnished the special apparatus required for this huge laboratory project.

The new laboratory is located at Western Avenue and 15th Place, Chicago, with general city offices at 708 W. Madison St., Chicago and a branch at 1988 E. 66th St., Cleveland, Ohio. A railroad siding and switch-track located in the Midland Warehouses at Western Avenue and 15th Place, Chicago, makes it possible to handle any sized job speedily and efficiently, by having it delivered to the tube-room of the Gordon Laboratory direct from freight cars.

Sensitive Research Instrument Corporation announce the removal of their plant from 142-154 East 32nd Street, to 4545 Bronx Boulevard, New York City.

Lubricant Tester

THE Timken Roller Bearing Company has developed an apparatus for testing the load carrying capacity of lubricants that has some very interesting features. It was originally developed for use in the company's own laboratory as a means for obtaining accurate information on the effect of different lubricants on Hypoid and spiral bevel gears in automotive axles, and to test lubricants in connection with many intricate industrial bearing problems. Its usefulness is not confined to laboratory or automotive work; it is equally suitable in industrial plants, power plants, or where it is desirable or necessary to determine the efficiency of lubricants for given conditions of service. In addition it can be used with equal effectiveness to obtain data on the relative efficiency of different bearing metals under various conditions of load, speed, temperature, or with different lubricants.

The apparatus consists essentially of a cast iron base which supports the testing mandrel, 2 levers and a container holding about a gallon of the lubricant to be tested. In detail, the tank is mounted on top of the base, and just under it is an electric heater, used to raise the oil to any desired temperature up to 210°F. The oil flows from the tank, over the test piece, to a sump in the base by gravity, the rate of flow being adjusted by means of a valve in the line. From the sump, the oil is pumped back to the tank by a small pump located in the base, and belt driven from the testing mandrel. The latter extends through the base, and may be either direct or belt driven by a variable speed fractional horse power motor. The mandrel is mounted in 2 bearings, so arranged as to hold it rigidly in alignment and is tapered at the test end to receive the tapered cup of a bearing. This cup, which forms one of the test pieces is held in place firmly by a nut on the end of the mandrel, which is threaded to receive it.

The lever system, which is the most important part of the device, consists of 2 levers, one above the other. The upper is called the load lever, and the lower the friction lever, for reasons that will appear. The upper, which carries the test block is pivoted on a knife edge mounted in the lower lever. The latter is also pivoted on a knife edge and is provided with a stop at the unloaded end. By virtue of this arrangement the test block is always parallel to the revolving cup and the unit loading over the length of both pieces is always constant. The test block is a small piece of metal about ½" square by ¾" long, hardened to Rockwell C-60 and ground. It is inserted in a notch in the loading lever and held in place by a wedge. In case bearing metals are to be tested either the test block or the cup or both can be made of the appropriate material. The friction lever is provided with a vernier scale and a sliding weight for obtaining accurate measurements and both levers are equipped with hangers for carrying adjustable weights. A welded steel housing is provided to cover the end of the mandrel and levers.

The operation of the device is substantially as follows: Assuming both test pieces in place, the driving motor or line shaft is brought up to the desired speed and the lubricant, heated to the required temperature, is allowed to flow over the test block. The loading lever is then loaded by means of weights until the desired unit pressure is obtained between the test pieces, a chart being furnished with the apparatus which gives the necessary weights on the loading lever per 1,000 lb. of unit pressure. If only the load carrying capacity of the oil is to be determined, the test block is removed after 30 minutes running, and examined for signs of scuffing. The degree of scuffing determines the relative load carrying capacity of the lubricant. In case the coefficient of friction of the lubricant is desired, weights are added to the friction lever until it moves away from the stop. Loading the upper lever causes the friction on the test block to move it forward horizontally, unbalancing the friction lever until it rests on the stop. This condition is compensated by adding the weights on the friction lever, until the system is again in balance and the lever is off the stop. The coefficient of

friction of the lubricant is then calculated from the amount of weight it takes to balance the levers. It would be a simple matter if extreme accuracy in this regard was needed to provide a make or break electric circuit between the lever and the stop that would indicate, by means of a lamp, or some other device, exactly when the correct weight is reached. The same holds true, of course, in case different bearing materials are being tested. Not the least interesting feature of the machine is the permanence of the records it provides. The condition of the test block can be examined at leisure, as a means of analyzing the effectiveness of the lubricant under test.

New Transit-Level

(Warren-Knight Company)

THIS instrument resembles to a considerable degree the general design of all Warren-Knight transits, but differs from them principally as follows:

(1) The horizontal circle is held in position by automatic spring tension and is set to the zero reading by hand.

(2) The telescope cannot be plunged through the standards.

(3) The telescope is provided with bell metal collars similar to those on a wye level.

(4) The tops of the standards form dual bearings—a V and a Wye in each—the telescope axle being normally held in the V bearings by spring clips, with provision for instant release.

(5) The telescope and axle can be lifted out of the V bearings (the normal working position) and the telescope rested in the Wye bearings for checking the adjustments in the same manner as a Wye level.

The principal objection to instruments in which the telescope (with level vial attached) can not be rotated on its axis, is the inability to easily check and make adjustments. This objection has been entirely overcome in the Warren-Knight transit level by designing the telescope and standards, so that the telescope and axle may be easily lifted out of the normal working position in the V bearings and placed so that the collars on the telescope rest in the Wyes provided by the dual bearings (patent applied for) in the tops of the standards. The adjustments of the level vial and cross wires may then be tested or made by one person, (exactly as for a Wye level) without the use of any graduated rods or other assistance. The telescope, after testing (and adjusting if necessary) is replaced in its normal working position (with the axle in the V bearings) ready for use, with the assurance that both the crosswire and level adjustments are correct.

The telescope may be clamped in any position, either level or otherwise, and then brought to an accurate setting by means of the slow motion tangent screw.

The transit-level offers the distinct advantages of a fully protected graduated horizontal circle with double vernier reading to single minutes; an exceptionally liberal vertical angular range of sight above and below the horizontal (110°); full ¾″ shift of the instrument on the tripod plate; high power telescope with close focus lens combination; generally sturdy construction; U. S. Standard thread for tripod head and plate; and particularly the ability to check the telescope and level adjustments in the same manner as a Wye level.

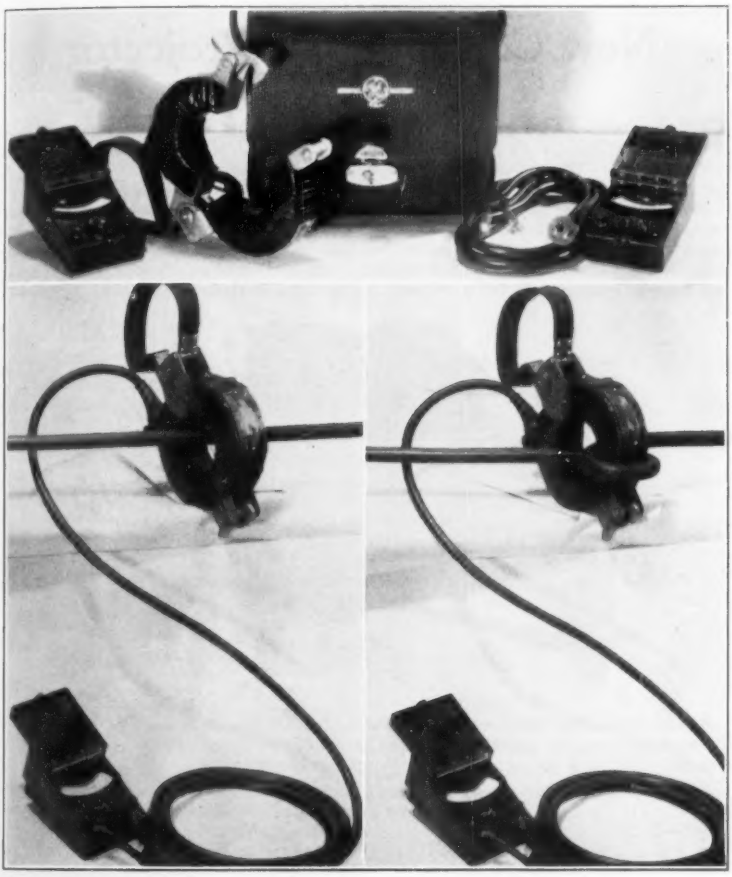
This instrument can be used to advantage for all kinds of work for which a surveying instrument is normally used.

Portable Testing Kits

(*General Electric Company*)

A NEW portable testing kit for alternating current, for checking current and voltage in industrial plants and for central station use, has been announced by the General Electric Company. The kit overcomes one of the most serious drawbacks to the testing of motors, transformers and like apparatus, since there is no need to disconnect leads or open the circuit under test.

View of kit, showing transformer, meters, leads and kit.



Ammeter reading actual current (one turn of wire through transformer).

Ammeter reading double current (two turns of wire through transformer.

The testing kit includes a new split-core current transformer, a companion ammeter, another portable instrument, a ten-foot two-circuit lead, and a leather carrying case. The transformer, ammeter and lead form a unit, and are calibrated together for maximum accuracy. Testing kits of various combinations can be made up to suit individual requirements and a 50-foot, two-circuit, calibrated lead can also be supplied.

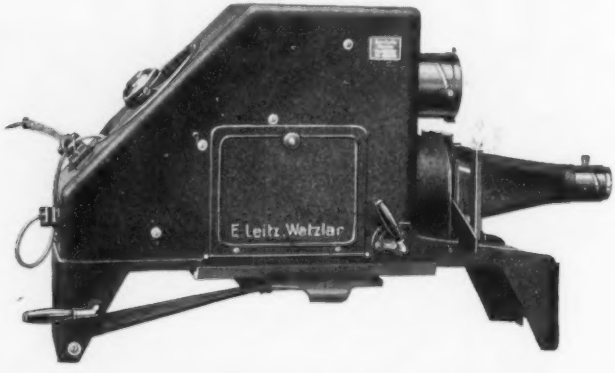
Opening with a flick of the thumb, the new transformer snaps tightly closed, encircling the line wire. The ammeter, of the AS-3 type, is sturdy, compact and accurate. Other instruments of the same type, single and double-rated ammeters and single, double and triple-rated voltmeters, are available. The carrying cases, of heavy black Scotch-grain leather and built to stand rough usage, are of three sizes to fit different combinations of instruments.

One method of using the kit is to have one turn of the line through the transformer. The ammeter then indicates directly on the scale the actual current in the line. When it is desired to measure current lower than could normally by read directly on the scale, there are two turns through the transformer. The ammeter then indicates double the current in the line. This method can be carried further by increasing the number of turns through the transformer, and obtaining the actual current by dividing the reading by the number of turns.

New Combination Projector

(E. Leitz, Inc.)

THE Projector "Vh" is equipped with four parabolic mirrors which act as concentration medium for the light rays emanating from the lamp and this effective mode of light concentration yields an exceedingly brilliant illumination of the opaque object. In addition, the four mirrors cast the light in an evenly distributed manner, eliminating the possibility of shadows when uneven objects are used for demonstration. The increased light concentration is likely to create heat absorption which acts disturbingly upon objects of sensitive nature and to obviate this, the projector "Vh" has been equipped with a ventilator-cooling-system which continuously blows cool air upon the projected surface. By means of this device, even the most sensitive specimens are protected against disturbing heat.



As additional advantages, beside the features cited, are to be mentioned the perfect optical system with which the projector is equipped and likewise its precision mechanical construction, not to overlook the exceedingly simple manner of manipulation.

The housing is made of strong sheet iron, covered with crystal lacquer carefully applied and burned to the metal surface to prevent its chipping off. The housing measures: extreme height—54 cm., extreme width—43 cm., extreme length—100 cm. The distance from the lower end of the supporting feet to the center of the opaque objective is 40 cm. and to the center of the lantern-slide objective 25 cm. The weight of the apparatus is 59 lb.

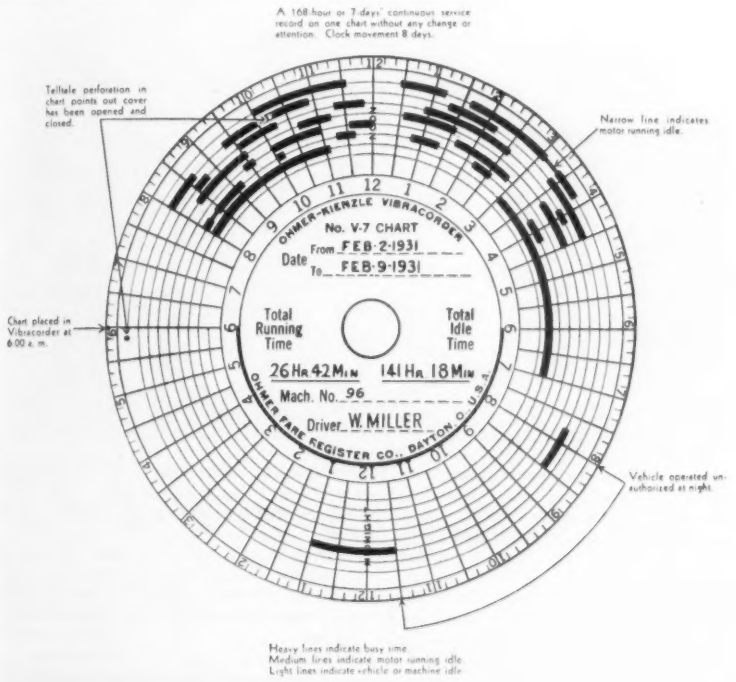
Opaque objects in widths up to 60 cm. and any available length can be placed upon the opaque stage and may be shifted to any required position, thus permitting the projection of any portion measuring 16 x 16 cm. Since the supporting stage for opaque objects is provided with spring and lever whereby books, etc., are automatically pressed firmly against the housing and yield a plane surface, the image on the screen appears flat and not curved. Frames are provided to hold pictures, photographs, maps, etc., permitting a quick change from one to another.

By merely turning a lever handle, the change from opaque projection to lantern-slides, or vice versa, is instantly accomplished. The projector housing carries opposite the lantern-slide objective a condensing system of 155 mm. diameter. The lantern-slide changer is of improved pattern, each lantern-slide snapping into position and when inserting a new one, the former is removed automatically.

Ohmer-Kienzle Vibracorder

(*Ohmer Fare Register Co.*)

THE Ohmer-Kienzle Vibracorder records the exact clock time that any motor vehicle or any piece of machinery is in operation or is idle. A small paper disc 5″ in diameter, taken from the instrument once a week, tells the whole story of 7 days' operation. It is operated by vibrations or oscillations which are always present when a motor vehicle or any piece of machinery is running.


A 168-hour or 7-days' continuous service record on one chart without any change or attention. Clock movement 8 days.
Telltale perforation in chart points out cover has been opened and closed.
Narrow line indicates motor running idle.
OHMER-KIENZLE VIBRACORDER
No. V-7 CHART
Date From FEB-2-1931
To FEB-9-1931
Total Running Time
Total Idle Time
26 Hr 42 Min
141 Hr 18 Min
Mach. No. 96
Driver W. MILLER
OHMER FARE REGISTER CO., DAYTON O. U.S.A.
Chart placed in Vibracorder at 6:00 a. m.
Vehicle operated unauthorized at night.
Heavy lines indicate busy time.
Medium lines indicate motor running idle.
Light lines indicate vehicle or machine idle.

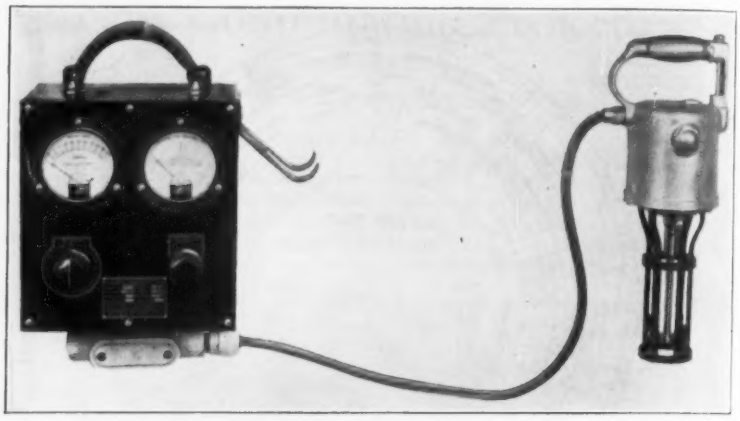
The Vibracorder resembles a small clock. As a matter of fact, it is a high grade, eight day, 6 jewel clock with an easily read dial which assists the driver of a motor vehicle or the person supervising the operation of machinery in keeping his work strictly up to schedule. In addition to moving the hands of the clock, the mechanism rotates a drum within the instrument bearing a specially prepared disc or chart under the point of a steel stylus or pen point.

The chart is laid out with spaces for minutes, hours and days, and for both day and night operation. A wide line is plotted on the chart by the stylus as it moves over the chart, vibrating in unison with the machinery. In a similar manner a light line is drawn by the stylus when the machine is at rest.

Electro-Viscometer

AN instantaneous electric viscometer for rapid measurement of the viscosity of finishing materials has been developed by the DeVilbiss Company. This device indicates viscosity of paints, varnishes, lacquers, oils, etc. in visual scale units just as the ammeter on the dash of an automobile indicates the rate at which the battery is being charged.

It has often been pointed out that faulty spray jobs, poor atomization, orange peel, dusty work, sags, etc., may be due to inaccurate thinning or viscosity control. The DeVilbiss viscometer measures the viscosity of finishing materials in the plant to an accuracy of within 2%.



The viscometer measures viscosity by rotating an impeller immersed in the liquid under standard electrical conditions. It shows liquid consistency as a dial reading. The effect of the viscosity load imposed by the liquid upon the impeller is determined by the effect upon the electrical circuit of the rotor driving the impeller.

The viscometer gives almost instantaneous readings in scale units, which for the sake of simplicity, have been called DeVilbiss units. The scale has been designed so that these units vary for a given liquid density approximately with the logarithm of the absolute viscosity. Calibration charts are built up permitting the converting of DeVilbiss units into such other established units as Saybolt seconds or Engler degrees.

When measuring the viscosity of any liquid with this viscometer, it is not necessary to change the liquid from one container to another. All measurements can easily be made in the original container. The liquid does not need to be transferred into the instrument. Instead, the instrument is introduced into the liquid in its original receptacle.

The advantages of the instrument are as follows:

1. It reads directly in viscosity units.
2. It is instantaneous—no time factor being involved.
3. No technique is required.
4. It is completely portable.
5. Values may be read or recorded at distant points, just like a pyrometer.
6. It operates from any light socket.
7. It cleans itself automatically and quickly.
8. Measurements are made in the original liquid container—the instrument is introduced into the liquid, not the liquid into the instrument.
9. Adequately accurate for all commercial viscosity measurements.
10. It is of vapor-proof construction, permitting its use in most hazardous environments.
11. It has no delicate parts—no involved mechanism.
12. It can be a permanent part of any engineering installation.

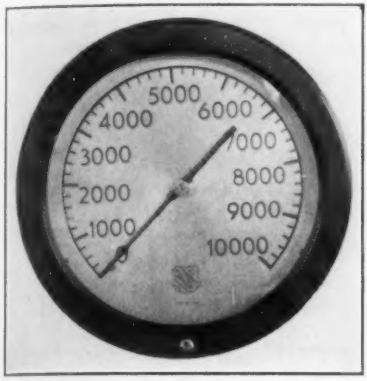
In operation, an attachment plug is connected to any light socket and the instrument connected with the line by means of a snap switch. The potential on the circuit is adjusted to a definite value by means of a control dial and the impeller is then submerged in the liquid. The push button on the handle of the impeller mechanism is depressed and the consistency of the liquid is simply read from the viscometer dial.

The viscometer is especially advantageous in factory and laboratory control work, where a quick, accurate and dependable reading is desired. Installation can be made in 15 minutes. In order to properly supply these instruments, it is only necessary to know the voltage, whether direct or alternating current, and if alternating, the number of phase changes or cycles.

New American Duragauge

(*Consolidated Ashcroft Hancock Co., Inc.*)

THE advent of high pressures and high temperatures, with the corresponding severe service, has emphasized the need for more durable pressure gages. On turbine work, for instance, with vibration and pulsations prevalent under high pressures and temperatures, the best ordinary commercial gage of the past was under an abnormal strain which it could not be expected to resist for any length of time. Power plants demanded a better and much finer gage which could be had flush mounted, for ordinary wall mounting, as well as for flush mounting with illuminated dial. Many industries had process work where the need for such an instrument was evident.



Under constant vibration and pulsations in pressure, the first part of a gage to wear is the movement itself. Bronze movements, even though they were bushed with monel metal, would not stand up. For the Duragauge, a special movement of nitralloy steel was developed, and for a period of over 6 months tests were run on sample movements. It was found that the nitralloy movement would out-wear 100 bronze movements.

Springs bored out of special solid steel alloy were also developed so that their expansion and contraction were absolutely uniform throughout the entire range. These springs made possible uniform graduations on the dial and, at the same time, enabled making the gage with an accuracy of ½%.

The sockets are made of forged steel, and the cases are die cast and usually furnished with black, hard rubber finish that are made absolutely water proof.

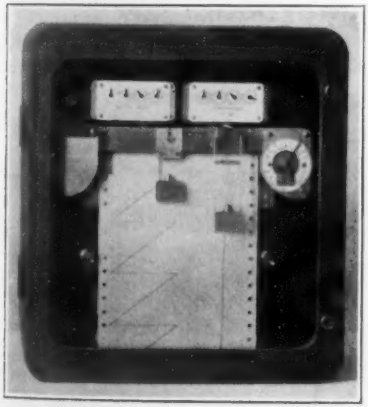
Another important feature is the unique pointer or hand which has an integral micrometer adjustment which makes it simple to compensate the gage for water leg in the field.

Type S KVA-Demand Meter

(*Sangamo Electric Co.*)

THE type S kva. meter is an auxiliary device controlled by 2 watthour meters, measuring the energy and reactive component, to give, on a single chart, the following information relative to the load:

1. The kva. demand
2. The kw. demand
3. The maximum kw. demand
4. The power-factor at time of demand
5. The reactive component demand
6. The time that the demand occurred
7. The energy component in kilowatt-hours
8. The reactive component in reactive kilovolt-amperehours.

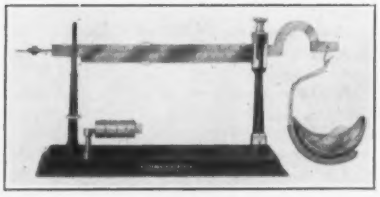


The measurement is so made as to define the kva. demand as the vector sum of the voltamperes in the individual phases, and, therefore, agrees with the generally accepted definition of power factor and kva. in polyphase circuits. The power triangle, corresponding to any given interval, is drawn on a strip chart.

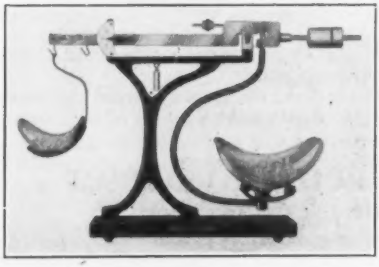
The energy is measured by a watthour meter and the registration is transferred through electrical means to a stylus which travels in a horizontal plane across a vertical paper strip. The integration of the energy is obtained with a watthour register similar to that on the watthour meter. The stylus is also mechanically connected to a pusher arm which advances a friction pointer, giving the maximum demand in kw.

Similarly, the reactive component is measured by a watthour meter connected so that it will integrate the reactive component, and its registration is electrically transferred to a similar register in the kva. meter, and in addition drives the paper chart.

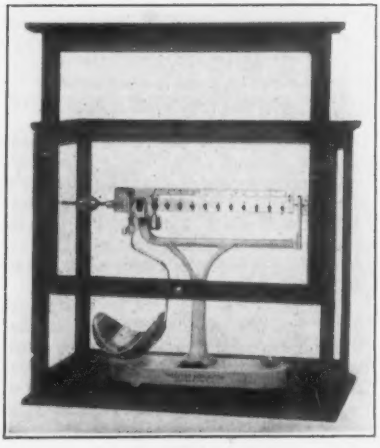
A synchronous motor performs the dual operation of, first driving an auxiliary stylus at a constant speed across the 12 equally spaced divisions at the right of the paper chart, and, second, at the end of a predetermined time interval, tripping and resetting to zero the stylus controlled by the energy component meter. Using one edge of the paper as one side of a right-angle triangle, the return of the stylus to zero completes the power triangle.



Seko Estimator



Seko Counter



Seko Decimal Weigher

New Counting and Estimating Scales

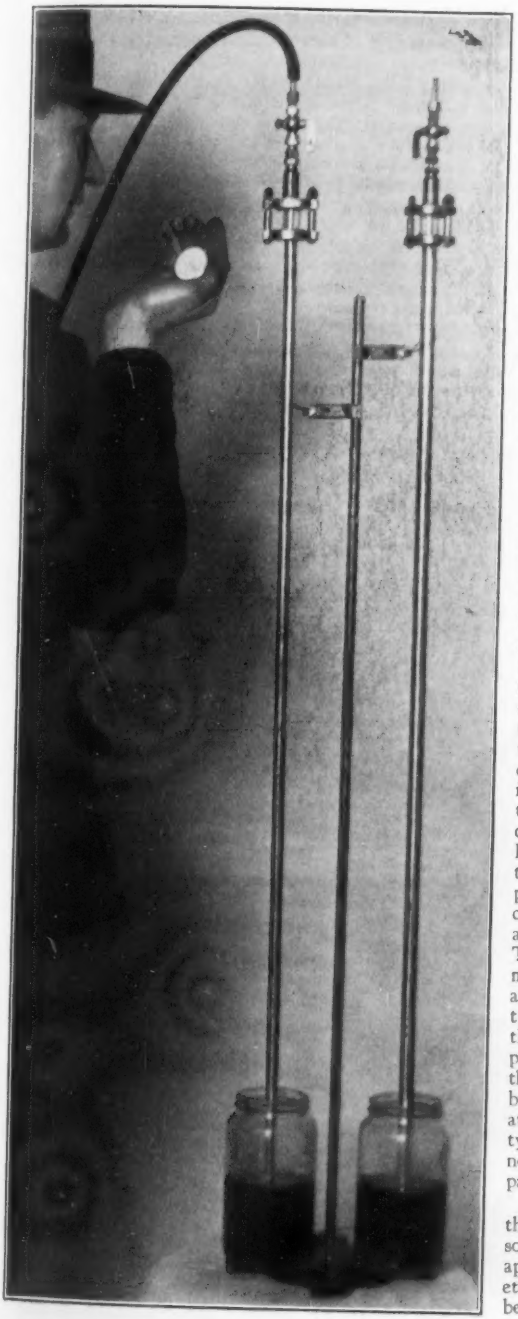
(Seederer-Kohlbusch, Inc.)

THE Seko estimator can be used to determine the weight of an article per gross, hundred or thousand. Capacity is 1 lb., sensitive to 1/1000 oz.

The divisions on top of beam show the weight by hundred or thousand. Lower divisions show weight per gross in lbs., ozs. or fractions of an oz. The weight of a sample can be read from the upper divisions, each graduation showing 1/100 oz.

The Seko counting scale can be used for packaging items such as screws, needles, buttons, tacks, etc. and for counting articles of every description. Scale will count either by 10 or 12. One piece in the weight pan equals 10 or 12 in the larger pan. Capacity: 4 lbs. Sensitive to 1/1000 oz.

The Seko decimal weigher is used for weighing or counting various kinds of materials in the plant, quotation or purchasing department. All readings are in decimal parts of a pound. There are no loose counterpoise weights. The instrument is direct reading and has a capacity of 1 lb. by 1/10,000 lb. or 500 g. by 50 mg.



COLLINS VISCOSITY TUBE

(*Arthur Collins*)

THE velocity of an air bubble rising in a liquid has proven to be a satisfactory method for the comparison of the viscosity or consistency. "Gardner and Holdt" of the "Paint and Varnish Research Laboratory," Washington, D. C. in 1921 established the glass tube with a rising bubble as a scientific instrument for the comparison of consistency.

Any glass tube with a bore of between .40 and 1.00 inches can be used to demonstrate the action of a bubble as it rises in a transparent liquid. The liquid to be tested is placed in the glass tube which is sealed at the bottom and an air space is left at the top. After plugging the tube at the open top it is inverted and the rate of travel of the air bubble upwards is the means used for comparing the consistency. To further explain the action, let one imagine that the liquid in the tube is made up of thin layers one sixteenth inch in depth. Each layer must await its turn to be accelerated from a position of rest and then caused to flow in a thin layer along the wall of the tube. The liquid has changed its molecular arrangement under a constant force. The velocity is no greater at the top than it is at the bottom. The penetration of the bubble goes through the same cycle at the bottom of the tube as it does at the top. Unlike other types of instruments there is no capillary tube or moving parts to contend with.

"Gardner and Holdt" based their determination of "Absolute Viscosity" on tubes of approximately .42″ in diameter. Of course the tubes can be of any convenient length

It is recommended that two tubes of different diameter be used. The use of two tubes provides a double check on the liquid and moreover establishes two points on a curve by which the velocity of the liquid in any diameter of tube can be anticipated. The use of the two tubes is the equivalent of using another type of instrument where the test is made on two capillary tubes of different diameter.

The cut shows the Collins brass viscosity tube. It is a brass tube provided with a short glass tube extension at its top through which the arrival of the bubble at the top can be observed. The liquid to be tested is first put in a vessel. The tube is supported so that its bottom is submerged in the liquid. The tube is filled by suction applied at the top. When the liquid is sucked up to a desired level in the glass section, the suction control cock is closed and the liquid will remain stationary. The bubble is started by either lifting the tube end above the liquid surface in the vessel or lowering the vessel and exposing the end of the tube. In either case when the end is above the liquid in the vessel, the liquid in the tube will start to run out. In doing so there will be created a bubble which will travel the length of the tube. The bubble starts automatically at the instant the tube is lifted. With the stop watch the elapsed time from the starting of the bubble until it breaks through the top surface is easily determined and is a direct means of comparing viscosity.

The Collins brass tube has several advantages over the glass tube. The effect of the size of the bubble has been eliminated by creating a very long bubble. Dark liquids do not obscure the glass. Tubes are of metal and of any length and uniform diameter. The stop watch is the medium through which the relative viscosity is determined. The viscosity characteristics of a liquid can be defined by stating the diameter of the tube and the reading of the watch.

Practically any liquid of any color and consistency can be tested with this tube.

New Binocular Research Microscope

(*E. Leitz, Inc.*)

THIS new construction is a boon to microscopists since by using a binocular body with inclined tubes, the observer can maintain a natural upright position while using the microscope.

This new microscope can likewise be used for monocular observation since an interchangeable means is provided for using either a monocular or binocular prism body.

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CONTROLLERS. Bulletin No. 990 describes the temperature-time controller, which automatically starts the operation when the set has been entered, brings up the temperature to the "boil," holds for desired duration without wasting time and then shuts off the steam and rings bell or flashes light to notify kettle man and boss dyer that the operation has been completed. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

CONTROLLERS. Bulletin 989 describes and illustrates a round form recorder-controller which has been devised for the canning of fruit, vegetables, meat, fish or any other food product. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

LINE TESTER. A circular describing a line tester for rapid and accurate leakage and resistance tests in electric circuits, lines and windings. Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

TESTING SET. A reprint taken from Siemens Review entitled, "A New Portable Testing Set for Current Transformers" by Otto Sieber, Siemens & Halske, Electrical Measuring Instrument Dept. Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

BRAKE TESTER. A leaflet illustrating and describing the Tapley Brake Tester which gives instantly stopping distance accurately, holds its reading till released, covers all speeds and conditions. Burton, Moore & Lush, 755 Boylston St., Boston, Mass.

MOISTURE METER. Bulletin 998 describes a moisture meter which accurately and quickly determines the moisture content of wheat. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

SILK WEIGHTING. Bulletin 988 illustrates a close up view of an actual silk weighting installation. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

CONTROLLED KILNS. Bulletin 994 entitled "Safeguard Lumber Profits with TAG Controlled Kilns." C. J. Tagliabue Mfg. Co. Park & Nostrand Aves., Brooklyn, N. Y.

THERMOMETERS. Bulletin 992 shows the actual size of the round form recorder used on water lines, storage tanks and particularly on washwheels, to determine the temperature. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

RECORDOGRAF. Form A-238 describes a real demonstration of the performance of a Recordograf placed on a truck. It illustrates the completeness of the information furnished. Ohmer Fare Register Company, Dayton, Ohio.

AIR OPERATED CONTROLLER EQUIPMENT. Catalog 4000 is divided into three sections as follows: Instrument Section; Valve Section; and Accessories Section. The Bristol Co., Waterbury, Conn.

INTERFEROMETERS AND INTERFERENCE APPARATUS. Catalog I contains a line of standard interferometers and other interference apparatus and some accessories for use with these instruments. Gaertner Scientific Corp. 1201 Wrightwood Ave., Chicago, Ill.

ELECTRICAL INSTRUMENTS. A loose leaf catalogue describing radio meters, test equipment, ammeters for the automobile, meters for the battery station and various other electrical instruments. Hoyt Electrical Instrument Works, 755 Boylston St., Boston, Mass.

ENGINEERING & SURVEYING INSTRUMENTS. Catalog B describes and illustrates engineering, surveying and mining instruments in general use. C. L. Berger & Sons, Inc., 37 Williams St., Boston, Mass.

MICROCHRONOGRAPHIC WHEEL. The title of this article by George R. Town is "Precise Measurement of Short Time Intervals by use of the Microchronographic Wheel." Reprinted from the August 1930 issue of the Review of Scientific Instruments. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

CALCULAGRAPH. A booklet entitled, "Elapsed Time Records" contains time-keeping information. Calculagraph Company, 50 Church St., New York, N. Y.

ENGINEERING ACHIEVEMENTS. Reprint 441 taken from the January 1931 issue of The Electric Journal is entitled, "Engineering Achievements of the Westinghouse Electric and Manufacturing Company During 1930." Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TRANSFORMERS AND AUTOTRANSFORMERS. A new 12 page illustrated Circular 1886 covering dry type transformers and autotransformers also tables giving their ratings, style numbers, weights and dimensions. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

WATER WORKS JOURNAL. No. 2, February 1931, contains the following articles: "Beverly Hills;" "Hydraulically Speaking Orifices;" "The Business Depression and the Drought;" "Artesian Wells of Ogden, Utah;" and "Watch Out for Your Water Waste and Save Money." Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

PROJECTORS. Pamphlet No. 1177 describes a combination projector used for opaque objects, lantern-slides, film-slides and micro-slides, etc. E. Leitz, Inc. 60 East 10th St., New York, N. Y.

THEODOLITE. Publication No. 811 describes the "Tavistock" transit theodolite. Several diagrams are also included. Cooks, Troughton & Simms, 15/17 Broadway, Westminster, S.W.1, England.

BATTERIES. Folder MK 1285 describes replacement batteries for electric service plants. Applications, construction details, and specifications for the nine sizes and types available are included. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CYLINDER TEST GAGE. A leaflet describing Model 165 cylinder test gage used for measuring inside diameter from ¼" up to 1½". Federal Products Corp., 1144 Eddy St., Providence, R. I.

CONTROLLERS. Circular 224-G contains charts which show how the frequency controller improves the operation of the power plant. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

PRECISION AUDIO FREQUENCY BRIDGE. A reprint from the December 1930 issue of The Review of Scientific Instruments, which tells how the audio frequency bridge was developed for its usefulness in testing resistors, inductances and condensers. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

PHOTOMETER, OSCILLOSCOPE, THERMOCOUPLE. Bulletins No. 281, 282 and 301 respectively describe and illustrate the Ultra-violet Photometer, The Bedell-Reich Stabilized Oscilloscope and the New High Sensitivity Vacuum Thermocouple. R. C. Burt Scientific Laboratories, 900 E. California St., Pasadena, Calif.

TRANSFORMERS. The February 1931 "News Letter" contains descriptions and illustrations of the laboratory and portable test transformers. A speed indicator and Paragon megohmer are also described in this letter. Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

AIR CONDITIONS. Circular 258-P describes how recorders enable the weather in a building to be controlled to within a fraction of the exact desired quality. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

PYROMETERS. Bulletin No. 531 describes Model 221 and Model 223 Pyrometers to measure the temperatures of small or medium size heat-treating furnaces. Illinois Testing Laboratories, Inc., 141 W. Austin Ave., Chicago, Ill.

CONTROLLERS. Circular 180-P describes a Potentiometer Controller designed for accuracy. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

QUADRANT BALANCE. A circular describing Nos. 406, 407 and 408 Improved Quadrant Balance. Julian H. Becker, Delft, Holland.

ANALTYICAL BALANCE. A folder describing 6 different types of analytical balances. Seederer-Kohlbusch, Inc., 149 New York Ave., Jersey City, N. J.

THE FOG HORN. The February, 1931 of this publications contains an article entitled, "Keeping a Textile Mill comfortable." Parks-Cramer Company, Fitchsburg, Mass.

RECORDING VOLTMETERS & AMMETERS. Leaflet 20512 includes voltmeters and ammeters. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MICROSCOPE. Pamphlet No. 1180 describes and illustrates a new binocular research microscope. E. Leitz, Inc., 60 East 10th St., New York, N. Y.

KNIFE SWITCHES. Leaflet 20509 covers the application and construction of knife switches. It also contains a table including ratings and style numbers. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

VISCO-METER. A circular describinng a instrument which enables the motorist to know continuously just what's going on in the lubricating system. Visco-Meter Corp., 315 Grote St., Buffalo, N. Y.

GRAPHIC METERS. A circular describing and illustrating graphic meters installed in plants which clearly reveal faults in the operating of plant equipment. The Esterline-Angus Company, Indianapolis, Ind.

SMOKE RECORDER. Circular 6591-G describes a smoke recorder in a large power plant. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

TOOL ROOM SPECIALTIES. A leaflet describing and illustrating standardized tool room specialties, used to aid accuracy in inspection and setup. The Taft-Peirce Mfg. Co., Woonsocket, R. I.

METERED CONTROL. Circular F-96-CC describes metered combustion control used to improve boiler efficiency. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

STEAM COSTS. Broadside No. 80-21 entitled, "Who'll I Charge This Steam To?" Brown Instrument Company, Wayne & Roberts Avenues, Philadelphia, Pa.

BLUE PRINTING MACHINES & ACCESSORIES. Catalogue M-29 contains concise descriptions of blue printing machines and accessories, blue print paper and drafting room furniture. C. F. Pease Co., 813 N. Franklin St., Chicago, Ill.

INSTRUMENTS, EQUIPMENT. A catalogue illustrating and describing instruments, equipment, supplies for engineers, draftsmen, and architects. A. S. Aloe Co., 1819 Olive St., St. Louis, Mo.

ELECTRICAL MEASURING INSTRUMENTS. A paper entitled, "Electrical Measuring Instruments in Refrigeration Research and Practice" by Crandall Z. Rosecrans. Discusses the use of various measuring instruments in research work on refrigeration apparatus and as aplied to commercial installation. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

VULCANIZED FIBRE. A booklet entitled, "Diamond Vulcanized Fibre" designed to acquaint men in industry with the properties of vulcanized fibre, with the manner in which it is made and how it is used. Continental-Diamond Fibre Company, Newark, Delaware.

GAS SATURATION CONTROL. Bulletin DMF 589 gives a complete description including several diagrams of this saturation controller put out by the Foxboro Co., Foxboro, Mass.

LIQUID METERS. Bulletins W-900-B-1, W-900-B3 and W-900-B4 cover cold water, hot water, piston oil, and gasoline meters. Worthington Pump and Machinery Corp., Harrison, N. J.

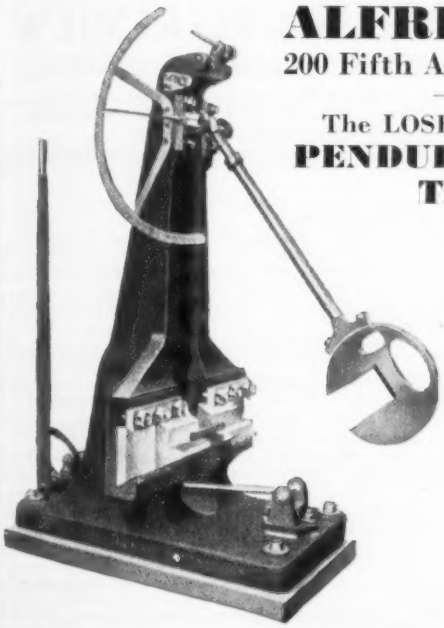
BALANCES. A booklet illustrating and describing Heusser Assay, Micro-analytical and Analytical Balances. Mine and Smelter Supply Co., 225 Broadway, New York, N. Y.

COMPASSES. Catalogue No. 53 describes and illustrates liquid compasses and nautical instruments. E. S. Ritchie & Sons, 112 Cypress Street, Brookline, Mass.

ACOUSTIMETER. Bulletin No. E9 describes the Burgess Acoustimeter used for the measurement of sound intensity. Burgess-Parr Company, 111 West Monroe St., Chicago, Ill.

CARBON DIOXIDE METERS. Catalogue No. 3004 describes Brown Electric CO_2 meters combining convenience, accuracy and freedom from maintenance troubles. Brown Instrument Company, 4482 Wayne Avenue, Philadelphia, Pa.

THE GRAPHIC. No. 231 of this publication contains the article "Solving a Knotty Problem with Graphic Instruments" by E. A. Norton. Esterline-Angus Co., Indianapolis, Ind.



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and for: IMPACT TENSILE TESTS

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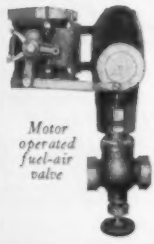

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MISCELLANEOUS

Diaphragm-Controlled Relay. (Durch Membran gesteuertes Relais). Elektrotechnische Zeitschrift, Aug. 28, 1930, page 1243.

Short description of a relay consisting of a diaphragm on which acts the variable pressure of air, gas, water or any other liquid.—H. A.

What Is Your Conception of a Filter? Radio Service, April, 1930, pages 11, 20.

Classification and brief discussions.—M. F. B.

Inspection and Repair of Tachographs. American Machinist, V. 72, March 27, 1930, pages 527-528.

The tachograph registers train movement, thereby permitting a close check on the operation of the train. Discusses briefly some of the details of the reapir of these instruments.—R. H. P.

Performance of Valve Mechanisms Is Recorded by Specially Designed Line of Instruments. J. Jehle. (White Motor Co.) Automotive Industries, April 26, 1930, pages 654-658.

The object of the article is to describe and demonstrate equipment for studying the behavior of any valve gear. Cam and spring combinations possessing a maximum number of faults were selected and analyzed in the test described.—G. N.

Application of Tolerance System Depends Upon Nature of Production Process. J. Gaillard. (American Standards Association) Automotive Industries, April 26, 1930, pages 646-649.

The author considers the relative merits of the unilateral and bilateral "basic hole systems" and points out why the unilateral system was chosen as the American standard.—G. N.

The Experimentation Station in the New Laboratory for Physics, Chemistry and Electrochemistry at the Technische Hochschule Stuttgart. (Die Experimentieranlage im neuen Laboratorium fur Physik, Chemie und Elektrochemie der Technischen Hochschule Stuttgart.) W. Jackel. Siemens Zeitschrift, Feb. 1930, pages 102-107.

Illustrated description of the new experiment station installed by Siemens & Halske in the Technische Hochschule Stuttgart, Germany.—G. N.

Determining Protection of Underground Pipe Through Proper Survey. P. J. Richards. (J. N. Richards & Son, Denver, Col.) Water Works Engineering, April 9, 1930, pages 491-492, 525.

The author stresses the necessity to discover the physical characteristics of soil, temperature and stray currents, before the protection of pipe and other underground structures of water distributing systems is decided upon. The nature and extent of coatings is considered.—G. N.

Atmospheric Conditions and Knock Testing. D. B. Brooks, N. R. White & H. H. Allen. S. A. E. Journal, July 1930, pages 56-68.

This paper constitutes a progress report on work undertaken with the object of ascertaining the order of magnitude of the errors likely to be introduced in knock testing by variations in atmospheric conditions.

Significance of Tests for Motor Fuels. R. E. Wilson. S. A. E. Journal, July 1930, pages 33-44.

In this paper the author discusses the significance of the various tests for motor fuels, particularly in the light of extensive research work along these lines in the past few years by various industrial laboratories and the United States Bureau of Standards. A bibliography of the literature on the subject supplements the paper.

Relay for Use in Regulatory Circuits. L. G. Wesson. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 179-180.

Diagram and description are given of an electromagnetic relay in which the operating circuit is automatically interrupted and in which undesirable sparking is prevented. A mercury trip-type switch is used.—M. E. H.

A Light-Metal Pantograph (Ein Leichtmetall-Pantograph). Georgi. Zeitschrift Vermessungswesen, Nov. 15, 1930, pages 815-820.

Built of Electron, collapsible circumscribing arm 72 cm, marked for the most usual ratios, made by A. Pessler Sohn, Freiberg-Sachsen.—H. A.

Glass-Stress-Tester (Glas-Spannungspruefer). Max Knopff. Glas und Apparat, Nov. 2, 1930, page 195.

If the cooling of glass takes place under unsatisfactory conditions inner stresses are the result which cause great losses if they can not be recognized before the glass enters the manufacturing process. As the glass assumes with such stresses the property to become double refracting it can be detected with this new stress tester which consists essentially in a set of double-refracting Nichols prisms between which a sample of the glass is brought. By another arrangement a quantitative determination of the quality of the glass can be made. The instrument is by Arthur Pfeiffer, Wetzlar, and Dr. Steeg & Reutter in Bad Hamburg.—H. A.

The Baader-Measurement of the Aging Trend of Insulator Oils (Ueber die Baadersche Bestimmung der Altersneigung von Iso ieroelen). v. d. Heyden and Typke. Elektrotechnische Zeitschrift, May 1, 1930, pages 640-641.

When making tests with the oil tester of Baader, a wide scattering of results was observed which to a very great extent was due to influences of temperature; hot weather gave high, cold weather low Baader-values.—H. A.

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Practical Test for Determining the Hiding Power of Paints. H. A. Gardner, G. G. Sward & S. A. Levy. Metal Cleaning & Finishing, June 1930, pages 537-538.

From a paper read before the American Society for Testing Materials. Describes method of determining hiding power by brushing out the paint upon a surface of checkerboard linoleum made up of black and white blocks. Results obtained by this method are higher than those obtained by the Pfund cryptometer, but they retain the same order of magnitude.—M. S.

Automatic Recording Waterproof Tester. A. L. Hodges. London, Edinburg, & Dublin Philosophical Magazine & Journal of Science. Aug. 1930, pages 327-328.

Device to record the time it takes for water to seep through various samples of waterproof materials. The sample is confined in a vessel having a free water surface. Water is placed on the sample and the clock of the recording apparatus started. When water seeps through it drops on a small amount of salt and an electric circuit is completed the lamp in the circuit lights and the recording pen is pulled to the side. The current soon dries the salt and the connection is thus broken until another drop falls on the salt.—R. H. P.

A Design for a Very Large Telescope. E. H. Synge. London, Edinburg, & Dublin Philosophical Magazine & Journal of Science, Aug. 1930, pages 353-360.

Describes a telescope in which a number of moderate-sized parabolic reflectors perform the functions of a single very large reflector. The design consists essentially in the assemblage of a number of similar reflecting telescopes pointed in the same direction, the images from which are ultimately superimposed in the focal plane of another reflector or lens, the resultant image containing the aggregate light of all.—R. H. P.

Testing and Rating of Fuel Fired Industrial Furnaces. Pt. XI. Measurement of Air Used for Combustion. Fuels & Furnaces, Jan. 1930, pages 75-78.

Describes method of measuring and calculating quantity of air required when it is supplied from several sources. For compressed air, orifice meter may be used. If the forced draft air is 5 lb. gage or lower, then a modified type of meter should be used. Presents equations and a chart. M. S.

Testing Refractory Cements. Charles McMullen. Fuels & Furnaces, March 1930, pages 358-359.

Abstract of paper read before American Ceramic Society, Feb. 16-21, 1930. Developed a small test furnace, heated electrically with "Globar" non-metallic resistor heating elements, which attains a maximum temperature of 1500 C. Includes transverse and load testing equipment. Tests were made by (1) heating the test bar to temperature and holding for 4 hrs., then breaking (transverse) at this temperature, which gives the strength of the cement after it is in use at a certain temperature; (2) Same as (1) except that bar is broken cold, which gives strength after cooling; and (3) heating bar to temperature, holding for 5 min. and breaking at this temperature, which gives strength on initial firing in use. Presents results obtained with a high-grade commercial cement.—M. S.

Practical Testing of Sheet and Strip for Drawing Operations. L. N. Brown. Metal Stampings, March, 1930, pages 239-242, 270.

Cup tests are usually made to determine drawability of sheets. On material up to 0.0625″ thick, standard practice is to use a ⅞″ ball or plunger with a 1″ diameter die with standard radius, and standard width test piece. On heavier material, most satisfactory results are obtained using the standard ball and a 2″ die. A testing machine has been developed which measures the load necessary to make cups of certain depths, as well as the depth of cup. Samples 3″ wide are used on tests of 0.0625″ or under, while samples 4½″ wide are used for heavier sheets. In testing, the load necessary to make an impression 0.1″ or 0.25″ deep is measured, together with depth at which the sample breaks, and the thickness of the material. All tests should be made under the same conditions. Hardness tests and the tensile test are also employed. Presents some typical results obtained.—M. S.

INSPECTION

Inspecting Bar Stock by Magnetic Analysis. R. R. Moore. Machinery, May 1930, pages 672-673.

Abstract of an article appearing in the Tradewind. Physical testing destroys or injures the material tested so it cannot be used. Etching and subsequent examination with a microscope is slow, tedious and considerably influenced by the human element. With the magnetic flow tester the steel bars to be tested are passed through two magnetizable coils placed a short distance apart and connected in series. In the center of each of these primary coils is a secondary coil. When the steel bar to be tested is passed through the magnetic field, an electromotive force is induced in the secondary coil. If the steel is normal and free from defects the induced electromotive force is the same as the primary. Any defect will distort the induced force. A special oscillograph records the fluctuations of both primary and secondary.—R. H. P.

Selective Inspection Cuts Assembley Costs. Walter G. Holmes. American Machinist, May 15, 1930, pages 806-810.

Automotive practice requires accurately fitted parts. Selective assembly and shim adjustments have replaced machining to such close tolerances Both of these are costly as the bearing has to be assembled, checked for error, reassembled, and rechecked. In the method discussed here use is made of various gages. The shaft and bearing groups are made by dividing the total tolerances between high and low limits into equal steps. The range for each division is chosen; a value of 0.0005″ has been found convenient. Each group is then identified by a quick drying paint and is ready for immediate assembly. Detailed explanation and 8 tables explain the practice fully.—R.H.P.

Lamps for Inspecting Small Holes. H. James. American Machinist, June 15, 1930, page 926.

Light is secured from a small flash-light bulb with wires soldered to it and connected to the flash-light batteries. Mirrors may be used for curved or angle holes.—R. H. P.

A Standard Test Set for Vacuum Tubes. M. H. A. Lindsay. Bell Laboratories Record, Oct. 1930, pages 85-89.

Construction and operation described.

INSTRUMENT DESIGN & CONSTRUCTION

Maintaining Precision in Production Lapping. Sydney Player. Machinery, May 1930, pages 686-688.

Abstract of a paper before the Machine Shop Practice Division of the American Society of Mechanical Engineers, at Newark, N. J. Describes a lapping machine and process whereby plug gages may be lapped within 0.00002 inch by machine.—R. H. P.

Combination Milling Fixture and Gage for Setting Cutters. William C. Landis. Machinery, May 1930, pages 700-701.

Describes and illustrates a device consisting of a hardened and ground gage block which is permanently attached to the fixture. The cutters are set by this gage block.—R. H. P.

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A Tool for Cutting Precision Threads. T. W. Hobbs. American Machinist, April 10, 1930, pages 627-628.

To secure fine double, triple and quadruple threads and accurate double-depth, fine V threads the writer used this method. Use a tool with a circular cutting section and a holder with angular adjustment. The tool was set by use of an angle gage. The readings on a graduated scale on the toolholder were recorded, making it possible to get precisely the correct setting when the same thread was cut again.—R. H. P.

Spacing Device for a Milling Machine. Matthew Harris. American Machinist, April 10, 1930, page 627.

Table screws of milling machines are not generally accurate enough. Greater accuracy is secured by use of a device consisting of a block fitted to slide in the dog slot of the table, and having one stationary and one spring actuated contact point, the tail of the latter extending slightly beyond the block; a bar attached to the knee and fitted with a contact point near one end; a movable bracket having a contact point opposite the one on the bar, and carrying a micrometer bead in an extension at the other end.—R. H. P.

Precision Boring in a Vertical Milling Machine. Marshall Bidwell. American Machinist, June 5, 1930, page 921.

Describes a master plate device used with a vertical milling machine to bore 3 holes in a limited number of boxes. Work was done with an approximate tolerance of 0.0005 inch.—R. H. P.

The Purpose and Design of the New Equipment at the Royal Observatory, Edinburgh. R. A. Sampson. Transactions Optical Society, 1929-30, No. 4, pages 219-225.

The author deals with the reasons which determined the form of the telescope—a Cassegrain reflector of 36 inches aperture and 54 feet focal length, serving a spectrograph of one, two or three prisms—and indicates the problems to which it is intended to apply it. These are, generally, the intensity of stellar light for different parts of the spectrum. It is pointed out that even an empiric treatment of this question led Adams to a method that has doubled our knowledge of stellar distances. A rheoretical treatment, comprising a discussion of the behavior of the photographic plate, led to fixing the temperature sequence. A slit spectrograph is required in order to deal with the lines. The state of the lines, combined with that of the continuous spectrum, conveys all the information that reaches us of the star's constitution and atmosphere. Subsidiary but highly interesting questions are those of selective absorption of light by the atmosphere of the earth. Behind these are the theoretical and laboratory investigations of the relation between intensity of light and the density of silver deposit on the photographic plate. The whole presents an attractive field.

AVIATION

A Radiobeacon and Receiving System for Blind Landing of Aircraft. H. Diamond and F. W. Dunmore. Bureau of Standards Journal of Research, October 1930, pages 897-931.

A radiobeacon and receiving system is described for use at airports to permit the blind landing of aircraft under conditions of no visibility. The system comprises three elements to indicate to the pilot the position of the aircraft as it approaches and reaches the instant of landing. Lateral position (that is, landing field runway direction) is given by a small directive beacon of the same type as employed for guidance on the airways, differing only in the use of smaller loop antennas and lower power. Longitudinal position along the runway (that is, approach) is given by a marker beacon. Height is given by an inclined ultrahigh-frequency radio beam, used in such a way as to provide a very convenient gliding path for the landing airplane, free of all danger from obstructions.

The Artificial Horizon. Elmer A. Sperry. Transactions American Society of Mechanical Engineers, Aeronautical Engineering, Oct.-Dec. 1930, pages 289-291.

This paper describes the "artificial horizon," an instrument developed recently to aid blind flying. Through the use of a gyroscope a gravity device is constructed with a very slow rate of motion that will maintain a horizontal position in an airplane with sufficient accuracy to make a most useful instrument. Test data for the instrument are given.

Some Improvements in Wind-Tunnel Balances Made Possible by Use of Vacuum Tubes. F. S. Eastman. Transactions of American Society of Mechanical Engineers, Aeronautical Engineering, Oct.-Dec. 1930, pages 217-222.

The paper presents some novel ideas on wind-tunnel balance design. It describes a new electromagnetic balance, which determines the current required to produce a balancing force. The claims are made, as against the motor-driven balance, that it is less costly, that it has no moving parts in the beam, is practically instantaneous in its response to sudden changes in force, can be quickly adjusted to almost any desired degree of sensitivity, and is readily adapted to recording devices to do away with the point-by-point method of obtaining curves.

Magnetic Compass with Pneumatic Transmission of Indications (Ein Magnet Kompass mit pneumatischer Fernuebertragung). Fr. Hauptmann. Zeitschrift Feinmechanik und Praezision, Nov. 15, 1930, pages 6-8.

Description of an instrument weighing only 1.3 kg., especially developed for use on aeroplanes. Ha

Flight Research on Maneuverability and Spin. John W. Crowley. S. A. E. Journal, Dec. 1930, pages 665-670.

Flight research conducted by the National Advisory Committee for Aeronautic embraces almost all the problems of flight but the author has confined his paper to descriptions of instruments and test methods used and some of the results obtained in the research that has been conducted on airplane maneuverability and spins. In the development of special instruments for this work the Committee has standardized upon an optical recording system to eliminate errors due to acceleration effects in the mechanism. The instruments described include a recording accelerometer, a recording turnmeter and a recording air-speed meter. These are used for accurately measuring accelerations and angular velocities of an airplane in any maneuver and also the speed of flight.

CHEMICAL ANALYSIS & APPARATUS

The Boiling Points of Constant Boiling Hydrochloric Acids. Walter D. Bonner & Roland E. Wallace. Journal American Chemical Society, May 1930, pages 1747-1750.

The boiling points of constant boiling HCl acid at pressures between 50 and 1220 mm. have been determined. A table is given showing boiling point, pressure, density (25°) and HCl%. A diagram of the apparatus is included.—M. E. H.

A Method for the Determination of Surface and Interfacial Tension from the Maximum Pull on a Ring. William D. Harkins & Hubert F. Jordan. Journal American Chemical Society, May 1930, pages 1751-1772.

An apparatus for the accurate determination of surface tension by the ring method is described. This consists of a chainomatic balance, supported by a machine which raises or lowers it with a minimum amount of vibration, and a special flask, designed to give a clean liquid surface, buried under the water of a thermostat. An apparatus for the measurement of the ring dimensions is also described. Preliminary measurements indicate that the ring method may also be used for the determination of interfacial tension.—M. E. H.

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A Screened Bridge for the Measurement of Electrolytic Conductance. I. Theory of Capacity Errors. II. Description of the Bridge. Theodore Shedlovsky. Journal American Chemical Society, May 1930, pages 1793-1805.

The theory of earth and shield capacity effects on alternating currents is discussed, and the results are applied to the Wheatstone bridge. The principles for the design of an electrostatically screened bridge for precision work are developed. An a. c. shielded bridge for precise electrolytic conductance measurements is described. Diagrams are given.—M. E. H.

A Conductance Cell for Eliminating Electrode Effects in Measurements of Electrolytic Conductance Theodore Shedlovsky. Journal American Chemical Society, May 1930, pages 1806-1811.

A multiple electrode cell for studying the elimination of electrode effects in conductance measurements is described. Data obtained with a KCl solution and 3 HCl solutions of different concentrations, using various measuring arrangements of electrodes, are given for 3 frequencies. A 4 electrode cell is found to give consistent results at the 3 frequencies without variations in the cell constant.—M. E. H.

Safety Device to Protect Heating Units. F. H. Fish. Industrial & Engineering Chemistry, Analytica Edition, Apr. 15, 1930, pages 197-198.

The simple device described suggests the use of a fuse in the heating circuit to protect the heating unit. A short is produced through the operation of a float in the liquid being heated. Diagram shows the arrangement.—M. E. H.

A Modified Thiele Melting-Point Apparatus. Ernest Conte. Industrial & Engineering Chemistry Analytical Edition, Apr. 15, 1930, page 200.

The Thiele tube is modified by the introduction of a bubbling tube which permits air to enter in such a way as to cause proper distribution of heat. Diagram shows the improvement.—M. E. H.

Modified Peterson-Palmquist Apparatus for the Determination of Carbon Dioxide in Air. Edwin P. Jones. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 195-196.

The modified apparatus consists essentially of (1) a bulb of known volume terminating in a uniform calibrated glass tube which is connected to a mercury levelling reservoir, (2) an absorption pipet, and (3) a manometer. Detailed instructions for carrying out a determination are given. —M. E. H.

Determination of Aluminum and Magnesium in Zinc-Base Die-Casting Alloys. Charles M. Craighead. Industrial & Engineering Chemistry. Analytical Edition, Apr. 15, 1930, pages 188-190.

Various methods applicable to the separation of aluminum and zinc in zinc-base die-casting alloys are discussed. The mercury cathode is suggested as a rapid and accurate method for the determination of Al and Mg in zinc-base die-casting alloys, and the results obtained by this method are recorded. A diagram of the apparatus is given. Bibliography, 16 references.—M. E. H.

Convenient Reflux Regulator for Laboratory Stills. Johannes H. Bruun. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 187-188.

The article describes 2 devices which control the reflux ratio and indicates the rate of distillation. They are modifications of a type which is used on industrial stills and they give a reflux ratio that is independent of the rate of distillation. 2 diagrams and 3 literature references are included. M.E.H.

The Baro-Buret—A New Accurate Gas Buret. Harold Simmons Booth. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 182-186.

Presented before the Division of Physical and Inorganic Chemistry of the Washington, D. C. Meeting of the American Chemical Society, Apr. 1924. There is described the construction and use of a new gas buret, in which the buret becomes the well of a barometer, thus enabling the experimenter to read both the pressure and the volume simultaneously with greatly increased accuracy and speed. Some applications of the instrument are cited, and diagrams given. 12 references. —M. E. H.

Duplex Weighing Tube. W. E. Eskew & Frank C. Vilbrandt. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, page 181.

This weighing tube incorporates the principle of a watch glass or weighing bottle provided with an accessible and easily discharging delivery end. Diagram is given.—M. E. H.

The Solubility of Gold in Mercury. II. Arthur A. Sunier and Chester M. White. Journal American Chemical Society, May 1930, pages 1842-1850.

Amalgams as dilute as 0.3% have been prepared and analyzed by a method described in this article, with a precision of 1 in 1000. An improved type of apparatus is described for shaking the solubility tubes and sampling the amalgams.—M. E. H.

The Micro Determination of Halogens and Metals in Organic Compounds. H. H. Willard and J. J. Thompson. Journal American Chemical Society, May 1930, pages 1893-1897.

A micro method is described for the determination of halogens and metals in solid or liquid organic compounds, based upon the oxidation of the sample with fuming sulfuric acid. The halogen is distilled into alkaline arsenite and then precipitated as silver halide. Metals may be determined in the same solution from which the halogen has been removed. A more compact apparatus can be used and the whole process is simpler and more rapid than in the macro method.—M. E. H.

Electrolytic Cell for Use with the Mercury Cathode. Arthur D. Melaven. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, page 180.

A mercury cathode cell has been developed to give a clean and easy separation of metals. Diagram is given. 4 bibliographical references.—M. E. H.

Substitute for Amalgamation in Testing Bituminous Materials for Melting Point, Ductility, and Float Test. Hans Eisner. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, page 176.

Amalgamated plates for use in the above tests are replaced by plates made rough and unpolished by etching, and coated with glycerol. 4 references.—M. E. H.

An Improved Victor-Meyer Molecular-Weight Apparatus. Mildred M. Hicks-Brunn. Bureau of Standards Journal of Research, Sept. 1930, pages 575-583.

The Victor-Meyer molecular-weight apparatus for determining vapor density is modified to permit measurements at two pressures, one atmosphere and one half atmosphere. By using Berthelot's method of limiting density most of the effects of departure from the perfect gas laws are eliminated. Experiments with hydrocarbons gave molecular weights differing from the theoretical by the following maximum deviations: Benzene, 16 experiments, 0.2%; hexane, 4 experiments, 0.24%; napthalene, 4 experiments, 0.06%.

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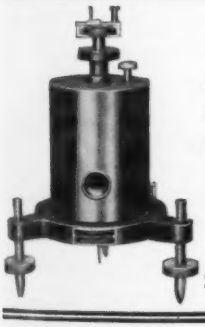

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X-RAY

The X-ray Method Applied to a Study of the Constitution of Portland Cement. L. T. Brownmiller and R. H. Bogue. Bureau of Standards, Journal of Research, October 1930, pages 813-830.
The X-ray diffraction method has been applied to a study of the constitution of Portland cement clinker.

A Vacuum Spectrograph for Precise Measurements of X-rays of Long Wave Length. Carl E. Howe. Review of Scientific Instruments, Dec. 1930, pages 749-757.
The spectrograph has 4 unique features which make it fitted for precise measurements (1) A slit system, consisting of five s its each one thousandth of an inch wide, excludes optical light and gives excellent collimation of the X-rays. (2) A universal grating support permits the plane grating to be set at any desired angle and to be removed in vacuo from the path of the X-rays without disturbing any adjustments. (3) A set of two parallel plate-holders at a fixed and known distance apart, placed at right angles to the slit system, permits accurate measurements of angles from the lines recorded on the two plates. (4) An X-ray tube with interchangeable targets is mounted on a micrometer slide permitting the focal spot to be readily lined up with the fixed slit system. The slit system, grating support and ways for the plate-holders are mounted as one unit which may be completely removed from the rest of the spectrograph for the purpose of adjustment. The apparatus is mounted on heavy concrete blocks to avoid mechanical vibrations. The spectrograph is maintained at constant temperature. Typical spectra are shown.

Compensation Method for the Measurement of Weak Currents. (Eine Kompensationsmethode zur Messung schwacher Stroeme). R. Jaeger. Elektrotechnische Zeitschrift, May 8, 1930, pages 681-682.
Air-condenser for calibration of X-ray dosimeters.—H. A.

X-ray Apparatus Used in Portable Setup. Iron Trade Review, Feb. 6, 1930, pages 73-76, 80.
See Instruments, Aug. 1930, page 24.—M. S.

MAGNETISM

The Technical Application of the Differential Iron-Tester (Zur technischen Anwendung des Differentialeisenpruefers). Fr. Wever & H. Lange. Elektrotechnische Zeitschrift, April 10, 1930, pages 538-539.
The paper discusses the possible sources of error in this kind of instrument which can occur, first, by errors in selecting and preparing the samples, secondly, by errors in the apparatus themselves, as i. e. wrong voltage or a non-sinusoidal wave form which can cause errors up to 5% of the actual value.—H. A.

PHOTOGRAPHY

A New Time-Magnifier of Zeiss-ikon Co. (Eine neue Zeitlupe der Zeiss-Ikon A. G. Dresden). W. Winzenburg, Zeitschrift fuer Feinmechanik und Praezision, Sept. 18, 1930, pages 1-4.
This apparatus for making slow-motion moving pictures operates with a continually running film and a ring of 30 mirrors all directed against the center of the ring. Fifteen hundred pictures are taken in each second, which means, for the ordinary reproduction of 15 pictures per second a time magnification of 100. The arrangement is described in detail and illustrated by photographs. H. A.

SPECIAL

A Recording Dust Concentration Meter for Blast Furnace Gas. A. W. Simon, Advance Copy. American Iron & Steel Institute, Oct. 1930, 14 pages.
Describes device based on passage of smoke-laden gas through glass boxes, with means for recording the amount of light absorbed.

A New Method For Recording Electrons. Percy H. Carr. Review of Scientific Instruments. Dec. 1930, pages 711-743.
A brief review is given of the use of photographic plates for the recording of electrons. Photographic plates are rendered more sensitive to the action of electrons by the application of a small amount of certain oils; but whether oiled or not, photographic plates are insensitive to the action of electrons when they strike the plate with a speed of less than 25 equivalent volts. This work indicates that the sensitizing action of oil is largely due to cathodo-luminescence of the oil, and that the failure of the photographic plate to record low speed electrons is due to the high electrical resistance of the photographic emulsion.

Automatic Recording of Machining Phenomena (Selbsttaetiges Aufzeichnen von Arbeitsvorgangen). A. Schulze & G. Zickner. Zeitschrift Verein deutscher Ingenieure, Sept. 27, 1930, pages 1359-1362.
An arrangement is described which makes it possible to record continually many physical or technical phenomena which can not be plotted point by point. Condition is that these phenomena can be connected with a change of an electric capacity in such manner that the latter changes in the same proportion as the quantity to be examined. The arrangement consists in a bridge method the indicator of which is a tube rectifier with a practically straight-line characteristic; the greatest sensitivity is about 0.01°F, absolute and relatively about 1×10^{-5}. A few practical examples demonstrate the usefulness of the method. 8 references.—H. A.

The Testing of Bearings (Die Lagerpruefung). E. vom Ende. Messtechnik, Sept. 1930, pages 235-239.
The problems of testing of bearings are discussed and illustrated by examples. The theoretical basis is explained and shows that the measurements have to determine mainly the temperature and momentum of friction besides which the play in bearing, excentricity, friction coefficient and heat of friction are of importance, further, the thickness of the oil film must be measured. A few examples of test arrangements are shown. Fourteen references.—H. A.

A New Arrangement for the Absolute Measurement of Number of Revolutions and Frequency Especially for Calibrating Purposes (Ueber eine Anordung zur absoluten Drehzahl und Frequenzmessung, insbesondere fuer Eichzwecke). Elektrotechnische Zeitschrift, Sept. 18, 1930, pages 1322-1323.
For very accurate absolute measurements of speed and frequency, the known methods are fairly tedious and expensive because beginning and end of the measurement are fixed arbitrarily. The new simple arrangement releases the counter for the revolutions by a second-pendulum. The required switches and relays are about the same as used in telephonic work. With a measuring time of about 30 seconds an accuracy of about 1 per mile can be obtained. The whole arrangement is built into a cabinet and operated by a dial.—H. A.

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A Hot-Wire Amplifier Method for the Measurement of the Distribution of Vortices Behind Obstacles. E. Tyler. London, Edinburg, & Dublin Philosophical Magazine & Journal of Science. June 1930, pages 1113-1130.

Several references are given in the footnotes. Describes a differential method, using 2 electrically heated platinum wires in conjunction with a valve amplifier for measuring the longitudinal spacing (l) of vortices formed behind cylinders of small diameter placed in a steady air stream. Measurements of the lateral spacing (h) of the vortex rows are also included, together with the values of h/l. A comparison with theory shows fairly good agreement for the average results only. The frequency of formation of the vortices behind cylinders, inclined plates, and aerofoils is determined by use of the same amplifier, and empirical formula included to account for the results.—R. H. P.

Remote Measuring by the Impulse-Frequency Method. Johannes Becker. Engineering Progress, June 1930, pages 161-166.

Discuss the need for remote control measurements in the control of power in central stations. Briefly reviews former methods. The impulse-frequency method is based on the principle of converting the variations in quantity to be measured into a sequence of impulses in such manner that the number of impulses per unit of time is always proportional to the measured quantity. These impulses must be converted into a continuous indication by the receiver. This method uses a transmitter, and induction meter carrying on its shaft an interruptor in the shape of a commutator. The transmitter works as a rotating-field instrument when measuring voltages, current, and power. When requisite connections are made it can be used for measuring frequencies. This device can be used for measuring other distant indications as water levels and other like things.—R. H. P.

A Method of Studying the Effect of Temperature on Photoelectric Currents. Dimiter Ramadanoff. Review of Scientific Instruments, Dec. 1930, pages 768-771.

The study of the variation of photoelectric current with temperature having been characterized by the difficulty of separating the thermionic from the photoelectric current, various schemes were used in the past (which author mentions) after trying which he resorted to the use of a transformer-coupled amplifier and a cathode ray oscillograph. The photoelectric cell described has 2 electrodes, a positive collector and a cathode consisting of a platinum strip coated with barium by a special process. The current from the photoelectric cell is made pulsating by interposing a rotating perforated disk in the path of the light illuminating the cell. It is composed of a direct current and of an alternating current of double frequency. It is fed to a 2 stage transformer-coupled amplifier. A condenser with a 6 megohm resistance on each side blocks any direct current such as the thermionic current and allows only the pulsating photoelectric current to be amplified. With the instrument described, any rapid changes in the photoelectric current which may occur at some critical temperature and which cannot be detected by a galvanometer, can be easily observed on the cathode ray oscillograph. The amplification can be increased for small photoelectric currents to meet the requirements.—M. F. B.

A Raman Effect Apparatus Using Standard Tubular Lamps. L. J. Buttolph. Review of Scientific Instruments, Nov. 1930, pages 650-653.

Essentially the apparatus described is a modification of the Raman effect outfit described by Reynolds and Benford in the Review of Scientific Instruments, Vol. 1 (1930) page 413, to adapt it for use with commercial tubular light sources and to permit flexibility in use. Spectrograms are shown, produced with filters for mercury arc and for neon arc. The housing is primarily intended for low pressure arcs having outside tube diameter of 1 inch, but the most intense mercury arc available may be used.—M. F. B.

An Apparatus for Obtaining High Speeds of Rotation. J. W. Beams. Review of Scientific Instruments, Nov. 1930, pages 667-671.

The method was first devised by Henriot and Huguenard (Comptes Rendus, Vol. 180 (1925) page 1389; and Journal de Physique et Radiometrie, Vol. 8 (1927) page 443) consisting essentially of both driving and supporting a rotor by means of a whirling film of air. The author states he employed the French method successfully but during course of experiments modified original design to secure greater stability and flexibi.ity. Improved apparatus and its operation are explained in satisfying detail. Rotor is shaped almost exactly like a toy top; flutings are milled on its conical under-surface, and it carries a stellite mirror instead of the handle of a top. Stator is essentially a corresponding conic hollow but many construction refinements are given. Results: speeds of 3000 R. P. S. with remarkable constancy of speed (comparable to that of audio oscillator), and nutation and precession of rotor so minute that streak of light reflected from mirror on screen one meter distant did not shift up or down by as much as one mm in one minute.—M. F. B.

A New Method of Producing and Controlling the Emission of Positive Ions. F. G. Cottrell, C. H. Kunsman & R. A. Nelson. Review of Scientific Instruments, November, 1930, pages 654-661.

Various glass anodes were constructed and are described, and voltage saturation curves for each are given, whence advantages of 1 construction appear. This construction is illustrated in detail. The central anode consists of platinum strip 0.5 mm wide and 0.1 mm thick around which was shrunk by melting a tube of potassium glass, leaving ends of platinum exposed for leads. The glass-covered filament was then bent into a U and immersed in molten potassium nitrate, where a potential of 5 to 10 volts between platinum strip and platinum electrode in molten salt bath electrolyzed potassium through potassium glass and plated it onto filament which thus became a reservoir of potassium. Advantages of this source of ions are that emission can be made very pure, large amount of alkali can be electrolyzed assuring constant supply of potassium ions at given temperature for long time, and at given temperature of emitting surface magnitude of positive ion current can be changed through wide limits by simply varying electrolysis potential.—M. F. B.

Measurements on the Dust and Tar Content of Gas Producer Gas. (Messung der Staub—und Teergehalte im Generatorgas). G. Neumann & F. Straeuhuber. Archiv fuer Eisenhuettenwesen, Sept. 1930, pages 151-154; Stahl und Eisen, Sept. 18, 1930, pages 1336-1337.

Report No. 79 of the Chemical Committee of the Verein deutscher Eisenhuettenleute. Exact heat balances of a gas producer can only be made up if the dust and tar content of the gas is determined directly. Since the usually applied methods for this procedure fail due to a plugging up of the glass tubes a new equipment was developed which can be successfully operated in tests over a long run. The results of practical tests are given, showing the benefits of the new equipment. —G. N.

SPECIFIC GRAVITY AND DENSITY WEIGHING

The Standardization of Weights. Philip F. Weatherill. Journal American Chemical Society, May, 1930, page 1938, Note.

The accuracy of the Richards method for the standardization of weights by substitution can be doubled by using the method of weighing by transposition, which makes the use of a set of tare weights unnecessary, and involves no more time or difficulty than the Richards method.—M. E. H.

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Device for Rapid Estimation of the Density of Small Amounts of Solids. Earle R. Caley. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 177-179.

The article described a microdensimeter, a graduated tube used for estimating the density of small amounts of solids. The narrow graduated tube is partially filled with a suitable liquid, and the level read with the aid of a reading microscope. A weighed sample of the solid is then introduced into the tube and the rise of liquid level again observed. Density is calculated.—M. E. H.

Centennial of Platform Scale Recalls Early Methods. Iron Trade Review, March 6, 1927, pages 90-92.

Outlines development of platform scale. Modern scales retain elements of Thaddeus Fairbanks' first design.—M. S.

PHYSICAL TESTING

The Testing of Automotive Rubber Parts Assembled under Compression. Part I—Deflection under Compression. Franz D. Abbott. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, pages 145-153.

Presented before the Division of Rubber Chemistry at the Columbus Meeting of the American Chemical Society, Apr. 1929. Data are presented in Part I to show that high tensile is no criterion of relative resistance to compression set and that hardness is not a measure of deflectability. In addition, deflection and permanent set under compression are greatly influenced by the size and shape of the test piece, the method of cutting the sample, the gage and methods of measuring it, and condition and kinds of surfaces in contact with the test piece. Compression and compression-set testing equipment are discussed, and some newly designed laboratory equipment is described. One piece of apparatus, the compressetometer, has been found extremely useful in making deflection, hysteresis, and set tests. These tests may be made under constant load or constant distortion. Eight references to the literature are given. Part II—Compression-Set and Some Special Tests. Pages 153-159. In Part II the main factors necessary to be considered in formulating a compression-set test are described and a proposed test is outlined. The constant-load test is preferable to the constant-deflection test. Flexometer and impact tests for bumpers are also described-MEH

Compressive Tests of Bases for Subway Columns. J. H. Edwards, H. L. Whittemore & A. H. Stang. Bureau of Standards Journal of Research, Sept. 1930, pages 619-626.

Tests were made of 3 welded bases and 6 riveted bases, 3 without base plates, and 3 with base plates to determine whether the welded design was satisfactory. The specimens were loaded with the base on a span of 12 inches. Some hand strain gage readings were taken to study the stress distribution. The strength of the welded specimens and the riveted specimens having base plates was practically the same. The H-section deformed greatly at the maximum load, and the stiffeners in the base buckled. The strength of the riveted specimens without base plates was about 60 per cent of the strength of the other types. At failure, eight rivets on one side of the specimen sheared. There was apparently no deformation of either the H-section or the angles forming the base.

Large Material Testing Machines. (Grosspruefmaschinen). Zeitschrift Verein deutscher Ingenieure, Oct. 4, 1930, page 1399.

Short description of a 100 ton testing machine for compression of a 6 m length, built by Maschinenfabrik Augsburg-Nuernberg. An accuracy of ±1% is guaranteed.—H. A.

Evaluation Tests for Rubber Vibration-Insulators. Franz D. Abbott. S. A. E. Journal, Nov. 1930, pages 600-604.

The author describes the most recent laboratory and semi-service tests of the rubber stock used in such insulators and several new machines for testing rubber for shear, impact, torsion, flexure, hysteresis, and compression set.

VIBRATION, SOUND, LIGHT, COLOR

Multiple Standard Colorimeter for pH Determinations. S. L. Leiboff. Industrial & Engineering Chemistry, Analytical Edition, Apr. 15, 1930, page 194.

The colorimeter was designed for matching colors of unknown solutions where a single standard cannot be used, particularly in pH determinations of wide range.—M. E. H.

Interference Measurements in the First Spectra of Krypton and Xenon. C. J. Humphreys. Bureau of Standards Journal of Research, Nov. 1930, pages 1041-1055.

The results here presented are compared with earlier interferometer measurements. The close agreement of our results with those of other observers as well as the small differences between our separate observations indicate that the wave lengths of the radiation emitted by krypton or xenon are reproducible within the limits set by the probable error of the observations. For the intense green and yellow lines of krypton, for which Perard, at the International Bureau obtained wave lengths 5,570.2892 and 5,870.9154A, we obtain 5,570.2890 and 5,870.9153A.

Precision of Color Temperature Measurements under Various Observing Conditions; a New Color Comparator for Incandescent Lamps. Deane B. Judd. Bureau of Standards Journal of Research, Nov. 1930, pages 1161-1177.

It is important in many kinds of scientific and technical research to know the color temperature of a source of light because for many common light sources it is possible to deduce from the value of color temperature the relative amounts of energy being emitted throughout the whole spectrum. Instead of measuring these relative spectral energies radiometrically for each incandescent lamp submitted for standardization, it is therefore customary to compare the test lamp as to color with a standard lamp previously tested radiometrically; that is, the color temperature of the test lamp is determined by comparison with a standard lamp. This comparison has been carried out at the National Bureau of Standards by means of either the 3° circular field of the rotary dispersion colorimeter or the 6° circular field of the Martens photometer. Preliminary to the construction of a color comparator which was to be designed to permit color temperature determinations with a maximum of precision an investigation was made of the effect on precision of various observing conditions. The conditions investigated included field size, width of dividing line, and convenience of the brightness adjustment. It was found that the simple apparatus used for these preliminary tests could be made to yield color temperature determinations of more than double the precision previously obtainable by visual comparison at the Bureau of Standards.

Infra Red Sensitivity of Cesium Oxide Photoelectric Cells, James W. Ballard. Journal of the Optical Society of America, November 1930, pages 618-623.

Measurement have been made of the relative spectral sensitivities of a number of cesium oxide photoeletric cells to visible and infrared radiations. For the region 5000A to 8000A where the results reported here overlap those of Koller and of Vedder, the sensitivities were found to check those previously reported. The infrared response has been found to decrease gradually from the maximum at about 7750A to approximately zero at 12,000A.

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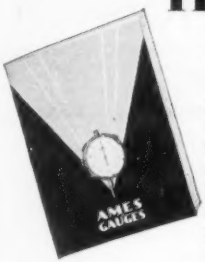

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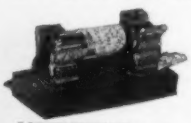

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WEIGHTS

R. RIMBACH, INSTRUMENTS, Vol. 4, No. 4, April 1931, pages 213-224, 5 figs.

Brief history of weights, Bureau of Standards procedure, discussion of constancy of weights, factor weights, etc. Conversion tables.

PRESSURE MEASURING INSTRUMENTS

M. F. BEHAR, INSTRUMENTS, Vol. 4, No. 4, April 1931, pages 225-242, 12 figs., 56 references.

Fourth and last instalment of Chapter XI of Handbook of Industrial Instruments. It includes the following sections:

17. Electrical methods of measuring pressure: resistance, piezoelectric.
18. Special high-vacuum instruments: McLeod gages, resistance gages, thermoelectric gages and ionization gages.

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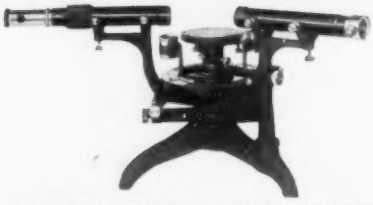

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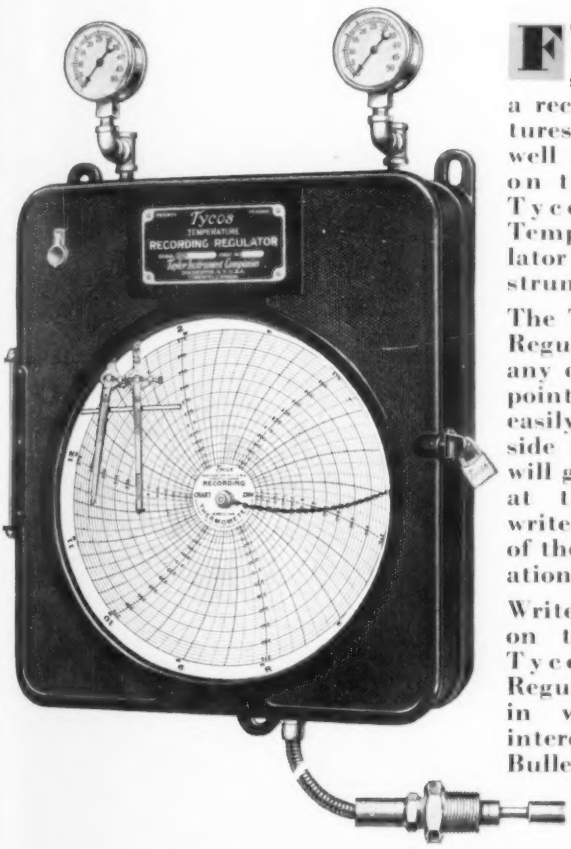

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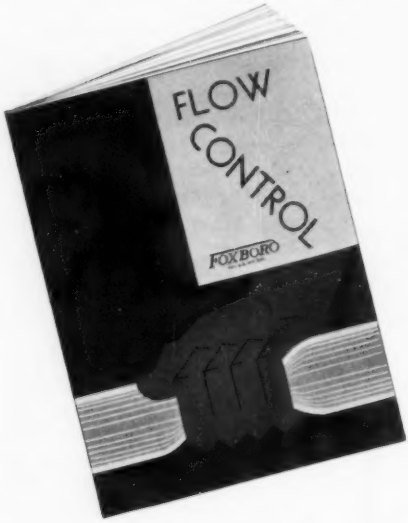

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